Electrical

The
Electrical Magazine.

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July to December, 1908.

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The
Electrical Magazine.

Vol. X. No. 1. LONDON. July 15th, 1908.

The World's Electric Progress.

Manchester Electrical Exhibition.

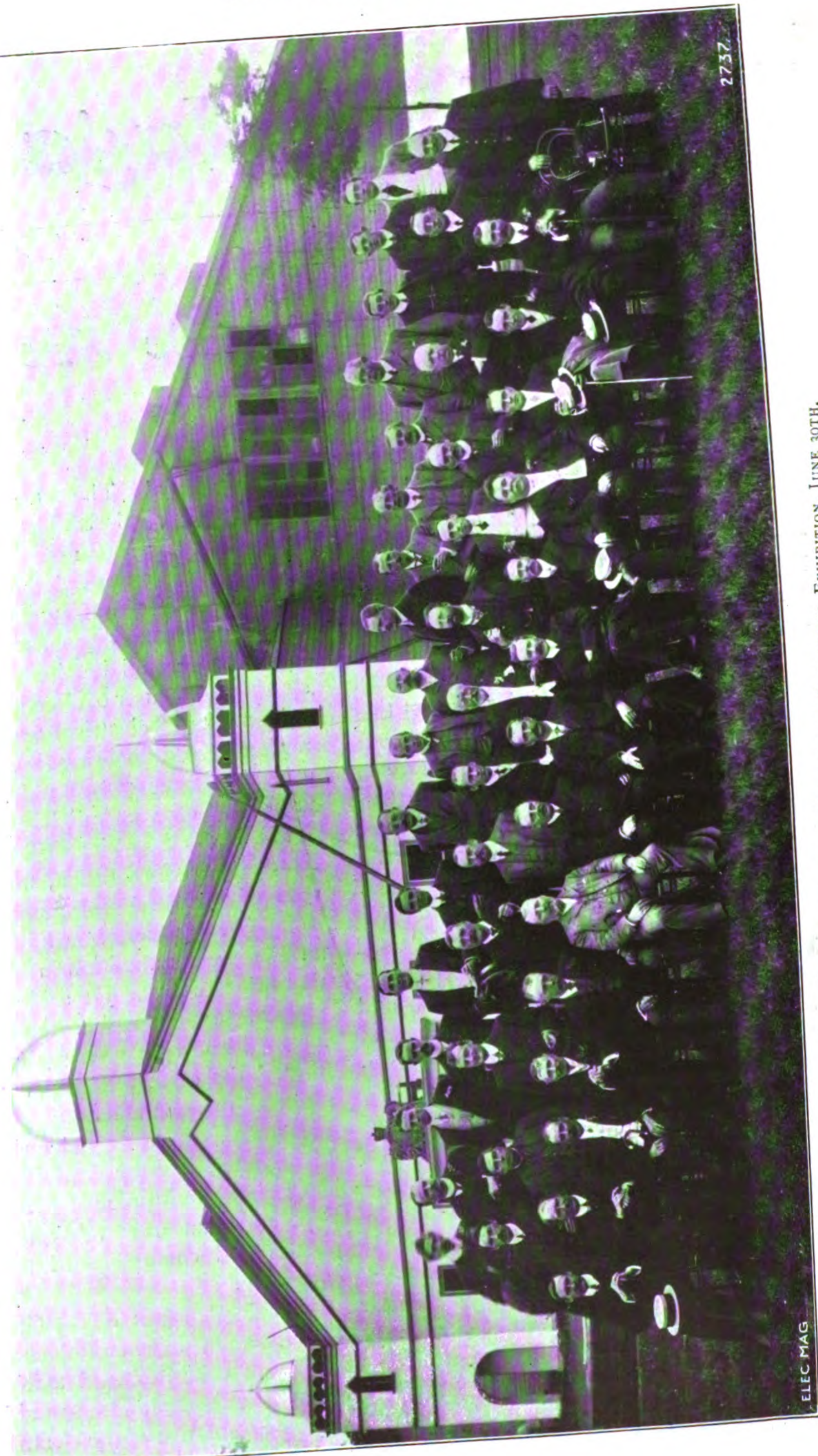
On the 7th inst., representatives of the general and technical press made an inspection of the buildings which are being specially put up for the Electrical Exhibition. The Exhibition opens on October 3rd, and judging by the present state of the work, everything will be complete and in full running order by that time. The main hall is exceptionally large, and will, it is said, accommodate even more exhibits than Olympia. As will be seen from the photograph, the building itself is practically completed. The foundations for the substation plant are now being put down, and the internal finishing of the building is being rapidly pushed forward. The site selected is one which has the dual advantages of being situated amid semi-rural surroundings, and at the same time being within easy access of the centre of the city. After a full inspection of the building had been made, the company enjoyed luncheon in the building itself and were afterwards given, in a series of short and concise speeches, many interesting facts concerning the organisation of the Exhibition.

Councillor W. Kay, who is Deputy-Chairman of the Manchester Electricity Committee, occupied the chair and welcomed the press representatives, indicating the appropriateness of holding such an exhibition in Manchester, which city he designated as "the centre of all centres of the commercial use of electricity." The speaker pointed out that an Electrical Exhibition in Manchester was desirable and necessary, and that it would certainly forward the electrical trades both from the manufacturers' and the public supply companies' points of view. The Exhibition would be the means of demonstrating to the user of electricity the latest developments in electrical application, and it further served to bring home to the non-user the benefits to be derived from the proper use of electric light and power.

Mr. H. Talbot, electrical engineer of the Nottingham Corporation, in seconding the vote of welcome to the press, said that it had been proposed some time ago to hold an Electrical Exhibition in Nottingham, but that this had been put aside to support the Manchester enterprise, the authorities of Nottingham recognising that Manchester formed the most fitting place for an exhibition of this character.

Mr. S. L. Pearce, City Electrical Engineer of Manchester, said the Exhibition had the full support of the Municipal Electrical Association, and that from thirty to forty municipalities had come forward to assist in the enterprise.

Mr. H. H. Bevis, of the General Electric Company, on behalf of the manufacturers, and as an exhibitor, said that there was no doubt that the Exhibition would be in every way representative of the electrical industries and interests of the country. At the close of



PRESS RECEPTION, MANCHESTER ELECTRICAL EXHIBITION, JUNE 30TH.

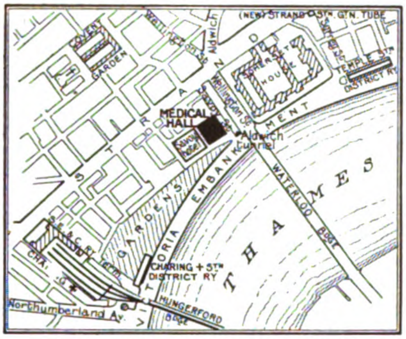
the last Electrical Exhibition, held at Olympia in 1905, the question of further similar exhibitions was discussed, and the conclusion arrived at that some three years should elapse before another be held. The Olympia Exhibition proved itself to be one of the most successful trade exhibitions ever held in this country. It resulted not only in a substantial sum being awarded to electrical charities, but over and above this a considerable amount was returned to the exhibitors, the Exhibition having been organised on a co operative basis. The Manchester Exhibition carries the same financial arrangements, and gives promise to be even more successful than the London Exhibition of 1905.

Mr. W. Davenport, Secretary, gave some interesting particulars of the building. He said that the Exhibition Hall now being erected was the largest temporary structure of its kind ever built in this country. It was 500ft. long by 180ft. wide, and thus covered about 100,000 square feet. Not only was the Exhibition to show the latest types of electrical apparatus, but particular attention was to be given to showing the commercial applications of electric power. Thus, there would be looms, machine tools, laundry machinery, and other machines as used in many of the leading trades and businesses, all shown under working conditions and driven by electricity. There would also be a series of exhibits showing the electric motor, as applied to coffee roasters and other domestic apparatus. The Exhibition, apart from its advantage to manufacturers and the trade, would certainly provide a wonderful educational lesson for the public at large, showing practically all of the variety of uses to which electricity is now applied.

It was universally conceded amongst the company that a great enterprise has been set on foot. Representative firms throughout the country are according the Exhibition the fullest support. The building and general work of organisation is well forward, and altogether we feel quite safe in predicting that the Exhibition will form a great public attraction and that Manchester will register a brilliant and unparalleled success in this undertaking.

New Headquarters for the I.E.E.

It was decided at a special meeting of the Institution of Electrical Engineers, held on the 30th of last month, to purchase the lease of the site and buildings known as the "The Medical Examination Hall," situate on the Victoria Embankment, now the property of the Royal College of Physicians of London and the Royal College of Surgeons of England, for the sum of £50,000. This momentous step on the part of the Institution was not agreed to without dissent. There were members who considered the financial position of the Institution did not warrant the purchase. As a matter of fact, the Hon. Treasurer (Mr. R. Hammond) in his statement showed that to complete the purchase would mean the raising of a loan of about £16,000, and that the coming year under the new conditions would result in a nett loss of something like £500. There were other members who protested that the building was too large and generally unsuitable for the purposes of the Institution. The strongest objection was that the matter was being rushed through, and that only a few of the members had been able to actively interest themselves in the suggested step; Major Cardew voiced this protest, stating that the present meeting of some 200 members could not be taken as representative of the Institution, and proposing that all members should be invited to vote on a statement. However, an amendment to refer the whole matter back for consideration by the Council was lost. The cause of the necessity for immediate decision was explained; only five weeks before had the question of purchasing the building been introduced to the Council, there was the competition of an important public body, and only a few days' option allowed the Institution. The Council were unanimous in recommending the purchase, and ultimately, the objections having been discussed an



Showing the Location of the New I.E.E. Building (Medical Hall).

the motion relative thereto lost, the original resolution to purchase was carried unanimously.

As will be seen from the illustration the new home of the Institution is an imposing building, and its position is an excellent one; it stands on the Victoria Embankment, facing one of the Embankment Gardens, and is situated between the Savoy Hotel and Waterloo Bridge (see accompanying small plan). It is midway between Charing Cross and Temple Stations on the District Railway, and is within a few minutes' walk of Waterloo, Charing Cross, and St. Paul's Stations, and is close to the new Strand Station of the Underground Electric Railways. It is almost at the point of junction of the tramways of the north and south of London. It is reached from the Strand by Savoy Street and Savoy Hill. Truly an ideal situation, pleasant in its environment, and easily accessible from every part of London. There are certain interior alterations which will be necessary for the purposes of the Institution, and tenants are to be found for spare room which is available. It is to be hoped that they will find their new acquisition a constant source of pleasure, profit, and usefulness.

The New Home of the Institution of Electrical Engineers.

The Mining Exhibition at Olympia.

WHEN this note meets the reader the Mining Exhibition will be in full swing. but although we are writing on the eve of the opening day, we feel quite safe in declaring the Exhibition to be altogether attractive and successful. On the 10th inst. the press were invited to make a preliminary inspection of the Exhibition, and on that day it is worthy of note that everything was to be seen practically in a finished state and in running order. This Exhibition is the outcome of three similar ones which were held in the years 1903, 1904, and 1906, but which were, however, entirely devoted to the colliery industry. In making this Exhibition cover all branches of mining, the promoter, Mr. H. Greville Montgomery, M.P., has certainly struck a line in the right direction.

Whilst the body of the hall is filled with such displays as haulages and winding gears; coal-cutters; pumps; picking, screening and surface plants; and in fact with every grade of machinery from the largest and heaviest power plants down to hand tools, the annexe, or smaller hall, and the galleries are taken up with a series of realistic representations of mining life and practice as found throughout the world.

In the annexe there is a large space devoted to a reproduction of a complete diamond-mining camp which, it is said, has been reproduced to the smallest detail from an actual camp in South Africa; indeed, the particular scene depicted formed a battlefield in the late South African war.

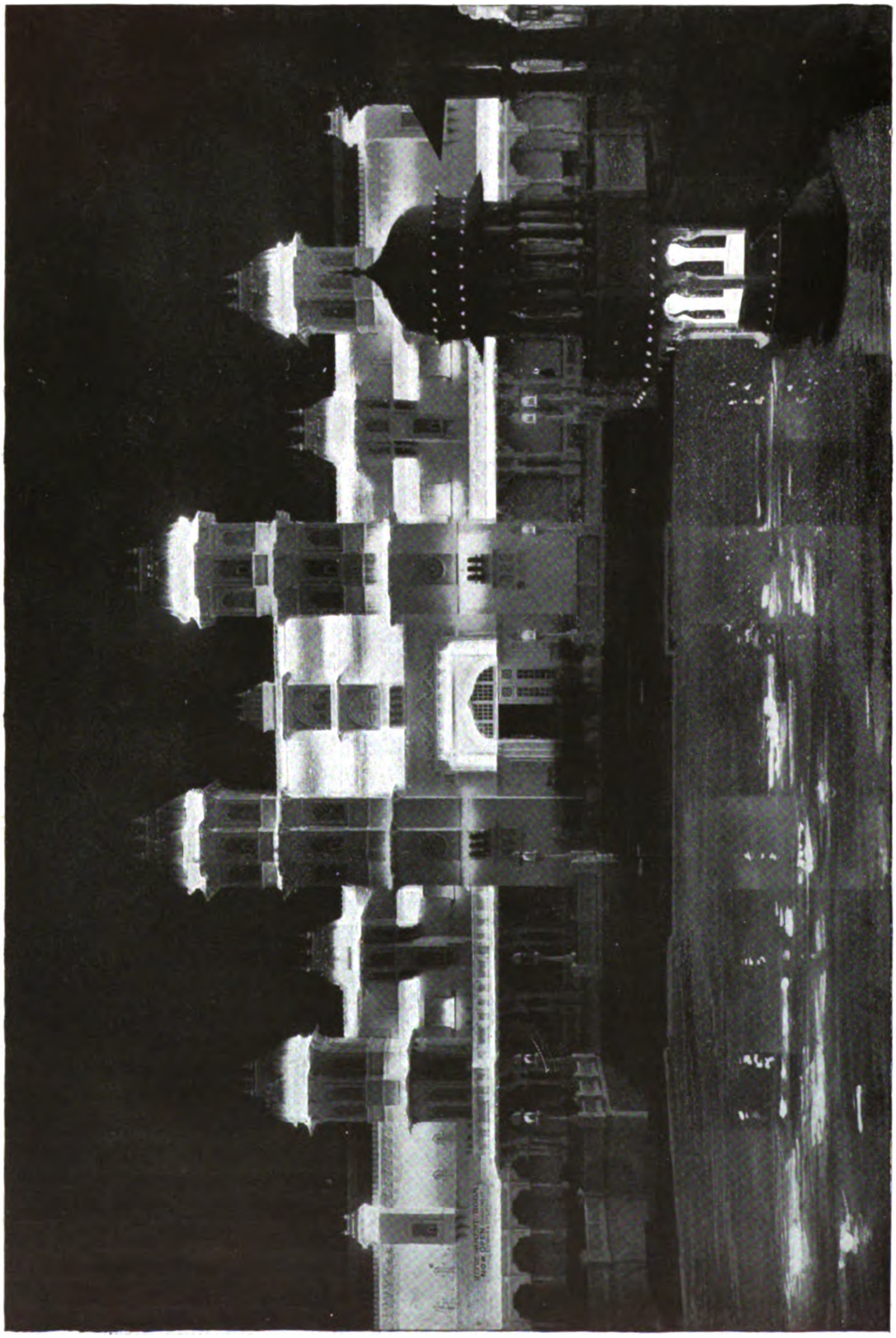
On the occasion of the press inspection, we were favoured in having Mr. E. P. Rathbone as a cicerone. Mr. Rathbone is a well-known mining engineer and had the unique advantage on this occasion of being able to speak of the several places and conditions as he had himself found them.

In the gallery are set out a number of side-shows. Here is to be seen a representation of the working face in a colliery, the quarrying of hard granite, the excavating of the well-known Bath stone. Then again we have an exceptionally fine reproduction of a Klondyke scene, where the gold occurs in the shingle beds of streams. Underground gold-mining is also depicted, and of exceptional interest is the scene showing the obtaining of gold by hydraulic mining such as is carried out in California, British Columbia, and in New Zealand. The process of this hydraulic mining is simplicity itself, but depends upon a considerable head of water being available. The water is discharged at extremely high pressure from nozzles against the face of the ravine or cutting. This breaks down the soft rocks, which are guided by water jets into a sluice over amalgamated plates, and the gold extracted as usual.

The public will undoubtedly take great interest in the stand exhibiting the mining industries of Rhodesia and the Rand. In this is included a very fine model of the Victoria Falls, from which readers will recollect it is intended to transmit electrical power to supply the entire power requirements of the Rand, distant from the falls about six hundred miles. Some exceptionally good photographs give very clearly a panoramic view of the whole of Johannesburg and indicate what a great hive of industry this district has become.

We can at this writing only give brief mention of what is indeed an exceptionally interesting and valuable exhibition, interesting moreover to the general public in that it illustrates to a remarkable degree the immensity of the mining industries of the British Empire. The extent of the coal-mining industry in this country we all know, but it is not everyone who realises how much indeed the life and interests of many of our Colonies depend upon what is recovered from the depths of the earth.

The next number of THE ELECTRICAL MAGAZINE is to be specially devoted to the subject of Electricity in Mining and in that number we will return to the description of the Mining Exhibition and give full details of those of the exhibits which are particularly worthy of note and which are connected more closely with the manifold applications of electricity in these great industries.



THE COURT OF HONOUR BY NIGHT.

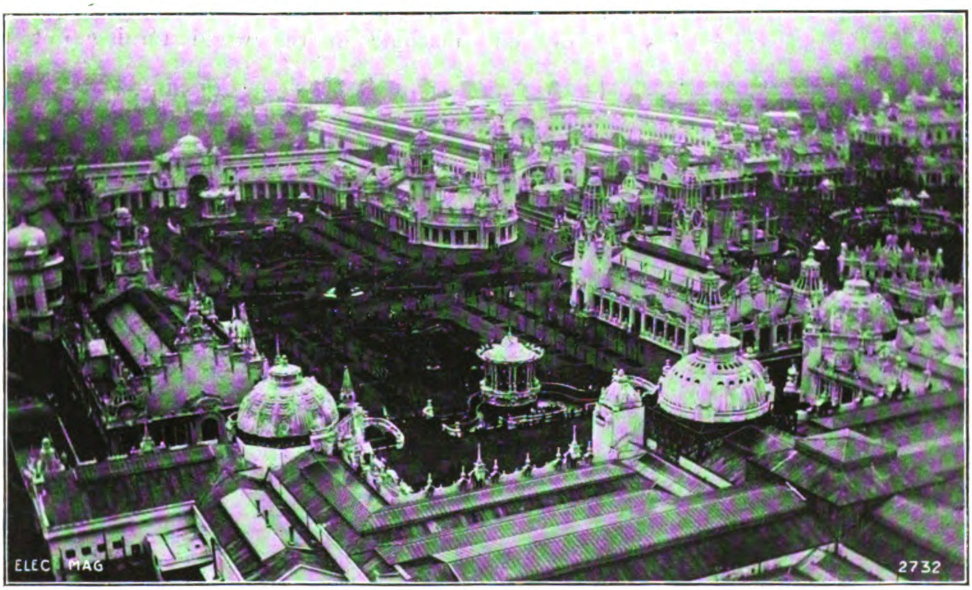
ELECTRICAL ENGINEERING

at the

FRANCO-BRITISH EXHIBITION.

INTRODUCTION.

THAT the Franco-British Exhibition is of supreme interest to engineers goes without saying, for is it not indeed from beginning to end a gigantic achievement of engineering—civil, mechanical and electrical? Those who were familiar with the rough unkempt waste of land rejoicing in the singularly appropriate name of Wormwood Scrubs, will realise the greatness of the work accomplished in so short a time, and will be inclined to forgive and forget the discomforts and disappointment of an exhibition "opened" before its completion. It is not within our province to attempt to deal with the Exhibition as a whole; even in confining our attention to its electrical interests only there is far more than can be given adequate attention in one number of THE ELECTRICAL MAGAZINE, and we have endeavoured as far as possible to give preference in the



BIRD'S-EYE VIEW OF THE EXHIBITION. TAKEN FROM A BALLOON.
[*Photo copyright Wakefield, Ealing.*

THE CANADIAN PAVILION.

tricity as the power producer. Wherever machinery is in operation or motion accompanies an exhibit, or where power is used for side-show, popular rides, sensations, &c., there, with very few exceptions, will be found the electric motor. Apart from the Palace of Machinery, wherein some hundreds of motors are engaged in the everyday service of driving all

following pages to those phases of the exhibition and those exhibits which are of the most modern interest and which serve to indicate to some extent the engineering lessons to be gleaned.

It is after sunset that one realises the predominance of electricity: the grandeur of the palaces, outlined and illuminated externally by hundreds of thousands of electric lamps, beggars description. The open courts and gardens and lakes are revealed in added beauty by innumerable arcs and other electric lights interspersed, aiding the effect of the distant luminous network of surrounding halls and pavilions, and relieved here and there by kiosks literally studded with electric lamps of all shades. Inside the buildings the same story repeats itself—everywhere is electricity the light-giver.

Not so prominent but none the less is the ubiquity of elec-

classes of machines and tools, it is to be noted that the Flip-flap—quite the latest form of locomotion—is driven by a 100h.p. motor; the Scenic Railway—combination of switchback and cable haulage—is electrically driven; a hundred and one essentials and luxuries, from cakes to tobacco, are produced on the spot with electrically operated machines. In the *Daily Mail* pavilion is shown the largest printing machine in the world turning out the

THE AUSTRALIAN PAVILION.

THE INDIAN PAVILION.

regular editions of that well-known organ and *The Evening News* at a maximum rate of 200,000 copies an hour and entirely dependent upon electric power for its operation.

Another noteworthy development of electrical practice in newspaper production is shown at the *Daily Mirror* pavilion, where at intervals during the day photographs of current news value are received by wire from Paris.

Some idea of the enormous amount of current used is gathered from the fact that the electrical system has been planned for a total of 5000h.p. Details of this electrical system, which is larger than that of many municipal undertakings, are given by Mr. H. J. Mills in an article elsewhere in this number. Mr. Mills is the electrical engineer to the Exhibition authorities and has carried out the entire work of installation from the first breaking of the ground to the present supervision of the completed scheme. Considering the amount of work which he has had to carry out under adverse conditions and in such short time the result speaks for itself in reflecting the highest credit upon the controlling engineer.

Turning to the exhibits proper, whilst there is great variety in the machinery section, it can hardly be said that the electrical manufacturers are well represented. This is particularly true of the French section, where, indeed, the exhibits of engineering industry as a whole fall far short of those of the British section. This is to be regretted, for the French have a great reputation as an engineering nation, and one would like to have seen them make a representative show in this direction. The British half of the Palace of Machinery is particularly attractive in the heavy engineering classes, many of our most prominent iron and steel and shipbuilding firms exhibiting unique specimens. In machine tools as well there are many exceptionally fine exhibits by leading makers, and it would appear, speaking generally, that this is one of the most progressive branches of British engineering at the present time. Without mentioning in detail any particular exhibits, it may be said that, whilst electrical plant is not shown so freely as might have been

ENTRANCE TO THE ELECTRICAL HOME OF THE COLLECTIVE ELECTRICAL EXHIBIT.

expected, there is little cause for complaint as to the scope and setting of the British engineering section.

Where notable firms have withheld their support the reason for this commonly given is that no business is likely to result from what is, after all, merely a gigantic pleasure fair, and not at all an industrial exhibition. Making enquiries on the spot we find that actual orders, and not a few, are being placed by visitors to the Exhibition amongst the engineering firms there. Surely it would be remarkable if here, where leading men and buyers from all parts of the world are sure to be found in large numbers, there was no actual business done. It is certain that those firms who have properly sought business—that is, by having trained salesmen in constant attendance, and good printed matter available—will secure it. Unfortunately many of the exhibits are denied of this business-getting property because no intelligent guide is at hand to explain the merits of the particular specialities shown, and to perceive the likely client when he comes along The leaving of a stand without attendance or in charge of a commissionaire or liveried figure head is absurd; if a firm goes so far as to incur the expense of space-rent and stand-fitting, surely it is worth while putting a skilled man in charge.

The great feature of the electrical representation is the joint exhibit brought together by the conference of the chief officials of electric supply companies. This is undoubtedly one of the most popular shows: appealing strongly to the householder and tradesman it will undoubtedly make many converts for the "electrical home" movement. But we are not so sure that the exhibiting firms will individually derive any very great benefit: the crowding together—and there is crowding—of exhibits of many classes, types and sizes from various sources, mostly competitive, is not conducive to much business being done. The average visitor must be somewhat confused and bewildered in this forest of electrical specialities; there is not the facility for confidential talk between the exhibitor and a promising enquirer. The arrangement has the usual advantage of co-operation—cheapness; but it may be taken that cheapness, as apart from economy, in exhibition matters is to be rigidly avoided. If exhibiting at all a firm should do the thing thoroughly and always aim to go one better than the competitor.

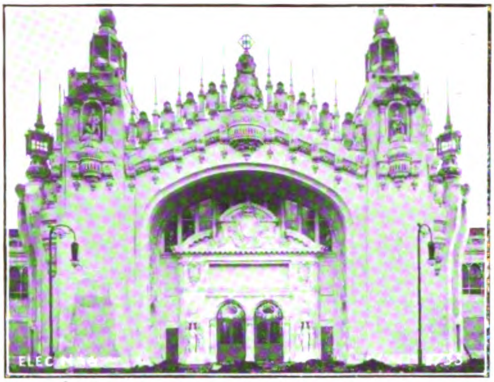
THE PALACE OF MACHINERY.

THE ELECTRIC SUPPLY SYSTEM OF THE EXHIBITION.

H. J. MILLS.

To the observant the Franco-British Exhibition is a colossal advertisement of electricity. The illuminations, which in their scope and effectiveness probably surpass anything of the kind ever seen, are throughout by electric lamps; the power supply is everywhere by electric motor. The examples of applied electricity, evident on every hand, are endless in their variety; there is very much in the way of real novelty, and it would be safe to say that no electrical engineer can pass through the Exhibition without learning something new of electrical practice. The electrical supply network feeding the Exhibition has been laid out for the huge demand of 5000kw., and even this does not represent by any means the total power requirements; in addition to this there are many complete generating stations or plants to be seen in operation, each providing current for some particular building or exhibit. Thus the Machinery Hall has a noteworthy central station to itself; this equipment is remarkable in that the gas-engine and the steam-turbine are brought together for parallel running on a common supply network. The gas-engine, of the latest Westinghouse type, of 750b.h.p., is supplied from an up-to-date Mond producer plant of 3000h.p. total capacity erected alongside. The steam-turbine is by Messrs. Parsons, of 2000h.p. capacity, supplied with steam at 160lb. pressure from a bank of three Babcock & Wilcox boilers fitted with

Illuminations of the Court of Honour.



ENTRANCE TO MACHINERY HALL.

the latest improvements in the way of superheaters and mechanical stokers. Then, again, the great Exhibition Hall of the Canadian Government has a generating station of 260kw. capacity, and the Australian Pavilion a plant of 230kw. output, both of these plants being of the Westinghouse gas-driven types.

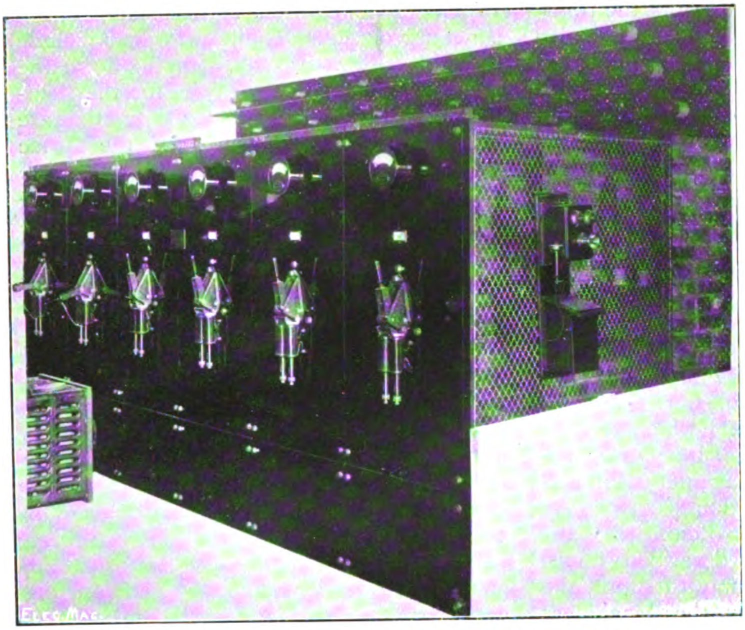
As will be readily understood, the planning of the electrical supply system and its installation has entailed an enormous amount of work being carried out in a short time and under generally adverse conditions. Energy is supplied in bulk from the public stations of the Kensington and Notting Hill Supply Companies, and also from the Corporation works of Hammersmith, the Hammersmith authorities being the main contractors for the supply since the Exhibition grounds are in their territory, the supply companies being sub-contractors under the Hammersmith Council. The supply companies deliver current in the form of 3-phase, 5000 volts, 50 periods, whereas the Hammersmith supply is single-phase, 2200 volts, 50 periods. In each case the feeders from the respective power stations to the Exhibition are in triplicate, and each enters all four of the Exhibition substations.

Of the four substations, the two situated near the Wood Lane entrance to the Exhibition receive the supply direct from the generating stations of the respective corporations ; the other two substations, which are alongside the Machinery Hall, receive their supply from the high-tension system of the Wood Lane substations.

The equipment of the intake stations at Wood Lane is entirely for alternate current. Only transformers are installed, and these supply the entire lighting requirements of the southern end of the Exhibition.

In each substation is installed a high-tension switchboard with main switches and fuses for controlling the incoming and outgoing feeders and the primary side of the transformers. The capacity of the bank of transformers in each substation is 600kw.

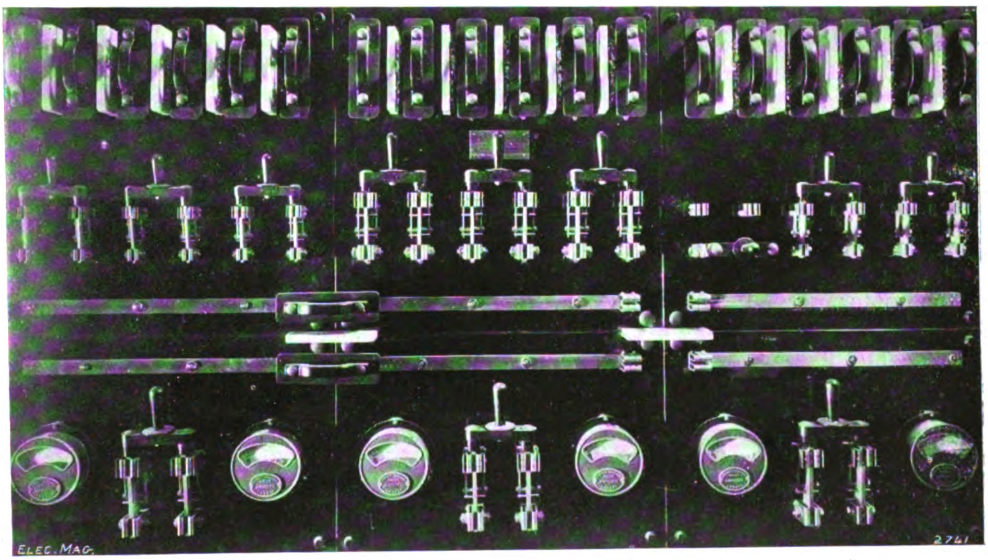
THE 2000H.P. PARSONS TURBO-ELECTRIC GENERATOR.



Substation Switchboard. High Tension.

neutral, and wound to give 220 volts between any phase and neutral. The secondary sides of the transformers are connected to the main low-tension switchboards. The single-phase switchboard is built up of nine panels, viz.: three meter panels, three for the transformers and three for the outgoing circuits to the various buildings, there being three circuits on each panel. The panels controlling the secondary side of the single-phase transformers contain one double-pole switch and two ammeters for each bank of transformers. The bus bars are mounted on the front of the board and are split into three sections, with switch fuses between them, each section feeding three circuits through double-pole switches and plug fuses. With the above

The secondary sides of the single-phase transformers are wound to give current on the three-wire system at 440 volts between the outers, whilst the three-phase transformers are star-connected with an earth



Substation Switchboard. Low Tension.

arrangement it is possible to work the transformers separately, each feeding three distribution circuits, or they may be coupled in parallel to feed the entire low-tension distributing network. The three-phase low-tension board is similar in design, with the exception that three-pole switches are used instead of double-pole, and that an ammeter is in circuit on each phase. The neutral bars are not mounted on the boards, but fixed on the wall at the back, and are connected to earth.

The substations near the Machinery Hall are not only equipped with static transformers for the lighting circuits of this portion of the Exhibition, but they also contain rotary converter sets which serve to provide a direct-current supply for the moving exhibits in the Machinery Hall and other parts of the Exhibition.

From the high-tension switchboard in the Wood Lane substation described above underground feeders go away to supply the other two substations by the Machinery Halls, two feeders from each board. One of the Machinery Hall substations receives single-phase only and is equipped with a high-tension switchboard for controlling the incoming feeders, &c., and has a low-tension switchboard similar in design and capacity to the Wood Lane single-phase substation described. Here also are installed a 250kw. motor generator of the G.E.C. type, the primary being 2200 volts a.c., and the secondary direct current at 500 volts and a d.c. power board. The direct-current power switchboard contains two machine panels and four feeder panels, and is also fitted with a double-pole switch and plug fuses for paralleling the bus bars on to the other direct-current board, which is erected in the three-phase substation. The direct-current panels of this substation control the output of the 600kw. Westinghouse gas-driven generator as well as the direct-current side of the motor generator. Of the direct-current feeders three run into the Machinery Hall to supply power to the various exhibits, and the remaining one supplies current to the 100h.p. Lancashire Dynamo and Motor Company's motor which provides the power for working the Flip-Flap.

In the three-phase substation, in addition to step-down transformers, the secondary supply of which are used for lighting service in the vicinity, there are installed two motor generators, a balancer set, and the necessary switch-gear for controlling the Parsons turbo-generator output. The transformers include three of 200kw. capacity, stepping down the 5000 volts supply to 220 volts for the lighting service. The two motor generators are each of 409kw. capacity, of the Bruce Peebles La Cau type, receiving three-phase current at 5000 volts and yielding direct current at 500 volts. The three-wire direct-current balancer is a 25kw. machine supplied by the Lancashire Dynamo and Motor Company, and is capable of dealing with an out-of-balance current of 200amp., the direct-current supply being run partly on the two, and partly on the three-wire system. The high-tension and low-tension alternate-current and the direct-current switchboard arrangements are similar to those described; in the latter case the direct-current three-wire board contains a machine panel for controlling the 1800kw. Parsons steam turbine set, a balancer panel, two motor-generator panels, and twelve feeder panels. The starting gear for the motor generators and the balancer are erected on pedestals placed by the side of each machine. The low-tension alternating-current and direct-current boards were manufactured and erected by the Universal Electric Manufacturing Company, the high-tension switchboard work being by Messrs. Cowans, of Manchester.

The substation equipment has in every case been put down in a thoroughly permanent manner. The high-tension switchgear is arranged in fireproof cubicles, the switches being of the Cowans oil-break type working in conjunction with Andrews automatic releases and cut-outs. The low-tension switchboards are of the same permanent character.

The 220 volt distributing mains are lead-covered, paper-insulated cables of three or four-core type, drawn into Sykes conduits. All branches, junctions and disconnecting boxes are located in brick pits with frames and covers, and from these pass the supply mains direct to the distributing switchboards in the buildings.

The distributor cable is divided into two separate circuits at the distributing board, one serving for the general lighting of the building or section, the other for the exhibitors' circuits. The complete work of installing the underground distributing system was carried out by Reed's Electrical Company.

CABLE LAYING. FEBRUARY, 1908.

type, and the wiring has been run in screwed gas-barrel for all the lower work up to the level of the roofs; above this the insulated wires are strung on porcelain bobbin-type insulators. The work has been carried out under L.C.C. and London Fire Brigade rules—no bare conductors are allowed, all conduits screw-jointed and earthed, and all arc-lamp suspensions are in duplicate—in fact the whole of the electrical work at the Exhibition has been put down on the most modern permanent lines. In concluding this short account of the electric supply arrangements, it is of interest to record the charges which are in vogue: the Hammersmith Council charge the Exhibition authorities a rate of 1d. per unit between sunrise and sunset and 2d. per unit for the rest of the day, there being a guaranteed minimum total payment of £10,000 between May 1st and October 31st.

The decorative lighting of the Exhibition includes both arc and incandescent lamps. There are in all some 1500 arc lamps installed; of these 400 of the Electrical Company's "Sunshine" type, and the remainder of the Maxim and Santoni enclosed and flame types. The arc lamps are arranged four in series, and as far as possible alternately on the three-phase and single-phase circuits so as to reduce the effect of failure of the supply. There are in all not less than 100,000 incandescent lamps in use for the illuminations on the buildings; in the Court of Honour alone there are installed 16,000 lamps wired on the "Fairy-land" strip system, and a further 5000 similar lamps for the outside illumination of the Palace of Music. The wiring and general installation work throughout the Exhibition has been distributed amongst a number of well-known firms, but in every case the incandescent lighting arc and power services are controlled by switches of the Berry-Skinner

CABLE LAYING. FEBRUARY, 1908.

ONE OF THE ENTRANCES TO MACHINERY HALL.

ELECTRICAL SCIENCE AT THE EXHIBITION.

W. T. CLOUGH, A.R.C.Sc., F.Ph.S., F.C.S., Head of the Physics and Electrical Engineering Department of the Technical College, East Ham.

To those who are at all acquainted with the extent of the application of electricity and magnetism in the production of measuring and detecting instruments, and with the enormous number of different types of electrical apparatus, a visit to the British Science Section of the Franco-British Exhibition will not call forth much surprise. The exhibits comprising the electrical section are arranged on a few stands in the centre of the Hall of Science, which is situated in the large hall at the Wood Lane entrance.

Though their number is small the variety of the instruments exhibited shows that an attempt has been made to utilise the available space to the best advantage. Indeed the area allotted to each of the branches of natural science is so very limited that it must have been a difficult problem for the exhibitors to decide what to show and what to leave out. Hence it is hardly surprising to find one of the first Daniell cells placed alongside one of the most recently invented instruments for the measuring of electrical wave-lengths, namely, Dr. J. A. Fleming's cymometer. On the same table is placed the original Wheatstone's bridge, and a large Russian lodestone in its ancient mounting, the latter being curiously adorned with oil paintings which presumably represent miners working on the side of a hill. This particular lodestone was used by Faraday to show the induction of currents by a natural magnet: Faraday's coil is also shown along with it. This consists of an iron bar wrapped round with a coil of thick insulated wire; one end of the coil is fastened to an amalgamated zinc plate and the other to a copper wire which is bent so as to touch the surface of the amalgam. The bar is put across the poles of the lodestone and then smartly knocked off, when a bright spark is seen to pass between the wire and the amalgam.

When we compare the exhibits of historical interest with the splendidly finished productions of the Cambridge Scientific Instrument Company, we are struck by the great gap between the position of electrical science say a hundred years ago and its position to-day. A glance at the long array of telephone and telegraph instruments shows clearly what a long way the science has had to travel to reach its present stage of perfection.

Historical.

Although the practical applications of electricity in its many branches only date from comparatively recent times many of the exhibits are historically important as being the work of men who have enriched science and the world by their brilliant achievements. It is impossible to say exactly when the first electrical phenomena were observed, but the Greek philosopher Thales, who died 548 B.C., is supposed to have been the first to notice that a piece of amber rubbed with various substances was capable of attracting light objects. During the next two thousand years scarcely any progress would appear to have been made. Then, in 1600, Dr. Gilbert, physician to Queen Elizabeth, made a large number of fresh discoveries of electrical phenomena, which earned for him the title of founder of the science. His discoveries aroused great interest in the subject, which was further studied by Boyle (1675), du Fay (1739), Franklin (1752), Volta, Cavendish, and Coulomb, and by many others, of whom in our own times we may mention Faraday, Tyndall, Ohm, Kelvin, and Hertz.

On one of the tables at the Exhibition is to be seen a battery of eighteen Leyden jars which belonged to and were used by

Henry Cavendish in the eighteenth century; also Wheatstone's electromagnetic chronograph and his rotating mirror apparatus. The hands of the chronograph are driven rapidly by clockwork, controlled by a vibrating reed, and can be put in and out of gear by means of a clutch worked by an electromagnet. Readings can be taken to the one-thousandth part of a second. The rotating mirrors were used by Wheatstone to find the velocity of the electric discharge from a Leyden jar along a wire. One of these mirrors is a small steel cube with four polished sides. It can easily be driven by the clockwork at one thousand revolutions per second without undue shaking.

Another noteworthy exhibit of Wheatstone's work is the original "Wheatstone's bridge" made by himself. It consists of a wire parallelogram mounted on a wood block. Terminals are provided at the four corners, and two adjacent sides have gaps with terminals for the insertion of two resistances, one the unknown resistance, and the other an adjustable known resistance. The ratio arms are equal and cannot be altered. This is the first bridge described by Wheatstone. Close by is the original Wheatstone's resistance box; this is a plug box. The unit of resistance is that of one mile of telegraph wire.

Here also are shown the rough-looking coils of copper strip insulated with silk used by Henry in his experiments on induced currents. These are believed to be the identical pair of coils used by him in America when he discovered the principle of induced secondary currents before Faraday completed his work in a similar direction in this country.

There is also shown the dynamical model first used to illustrate the principle of the primary and secondary circuit. This model was constructed for Clerk Maxwell whilst he was Professor of Physics at King's College, London, to illustrate his dynamical theory of the induction of currents. On the same table Prof. H. A. Wilson, F.R.S., exhibits apparatus used for measuring the induced electromotive force in an ebonite cylinder rotating in a magnetic field. This consists of a solenoid giving a field of 2000 C.G.S. units with 20amp., inside of which the hollow cylinder of ebonite can be rotated at 200 revolutions per second. The inside and outside surfaces of the ebonite have metal coatings which were connected to a quadrant electrometer through sliding contacts. With this apparatus it was shown that an electromotive force acts in the ebonite equal to $\left(1 - \frac{1}{K}\right)$ of that in a conductor. The same exhibitor also shows apparatus used for finding the charge carried by the ions produced in air by Röntgen rays.

The Telephone.

Following on these is a long series of exhibits illustrating the development of telephone and telegraph instruments. The first recorded attempt to transmit speech electrically was made by one Philip Reiss, a German schoolmaster, in 1860. The first transmitter he employed was, it is said, formed from the bung of a beer-barrel, hollowed out, and having one end closed with the skin of a German sausage to serve as a membrane. This interesting relic, however, is not exhibited, but amongst the collection is to be seen one of this enterprizing inventor's first telephone transmitters and also one of his receivers. The first speaking telephone was the invention of Alexander Graham Bell, a Scotchman who had settled in the States and become a naturalized American citizen. An early form of his telephone, which was brought to this country in 1878, forms one of the series exhibited. The first public exhibition of the speaking telephone in England was given by Mr. Preece (now Sir William Preece) in 1877 at the Plymouth meeting of the British Association. Two of his instruments are shown, one of them being a later form dated 1882.

After the advent of Hughes' microphone and Edison's carbon transmitter, a large number of improved transmitters of the microphone type were devised by different inventors. A Berliner microphone finds a place in this collection. In addition to these will be found a Dolbear telephone transmitter and an original form of Hunning's transmitter (1882).

Development of Telegraphy.

The development of modern telegraphy is illustrated in a similar manner. The telegraph of the present day was of slow and gradual evolution—so gradual indeed that it is practically impossible to point to any one man as being the inventor of telegraphy. Up to the year 1834 the telegraph for practical purposes had not been established on any large scale. Wheatstone's researches on

the velocity of electric waves in solid conductors appear to have directed his attention to telegraphy, in connection with the development of which he played an important part. In his first instrument five indicating needles were employed; subsequently the number of needles was reduced. An example of a four-needle instrument, dated 1837, is shown; also a double-needle instrument used at Buckingham Palace in 1851, and a number of other single and double-needle types. Here we also find Wheatstone's A.B.C. transmitter and a portable form of Breguet's A.B.C. set.

An important step in the progress of telegraphy was the invention of the "relay" by Edwin Davy. The Post Office pattern of Stroh's relay is exhibited. Another inventor who contributed very largely to the advancement of the subject was Morse, an American artist. At the present time nearly all telegraphy is done by means of the Morse sounder. An old form of sounder on sounding box, a Morse embosser, and a Morse bottle inker can be seen. The remaining exhibits in this section are of more than passing interest. A brief survey of these is the following:—

Wheatstone's A.B.C. type printer.
Wheatstone's automatic transmitter.
Wheatstone's automatic receiver.
Pneumatic despatch box.
Bain's chemical recorder.
Specimens of old pneumatic tube with carrier, laid in 1854, recovered in 1870.
Samples of the first underground telegraph line laid in London in 1844.
Various specimens of early telephone and telegraph cables.

Amongst the generally interesting curiosities to be seen are a mouse's nest found in a cable duct, a piece of a telegraph pole damaged by woodpeckers, a bough of a tree worn by telegraph wires, and the bell used by Queen Victoria on her Diamond Jubilee Day, 1897.

As an illustration of the difficulties with which telegraph companies have still to contend there is shown a short piece of an underground telegraph cable on the route from London to Penzance (317 miles), which has

Fig. 1. Submarine Growths on Telegraph Cable.

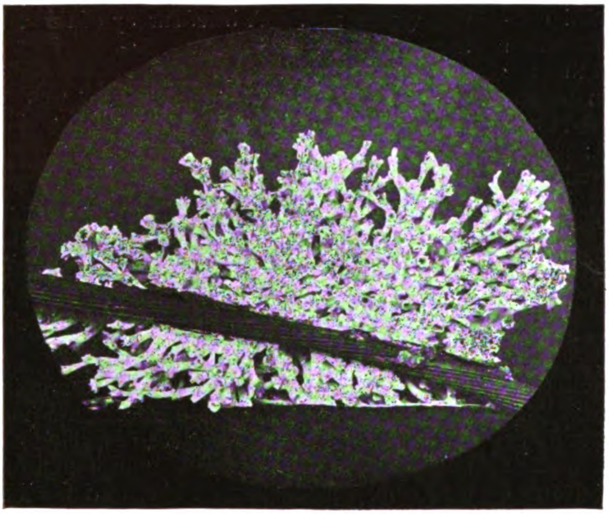


Fig. 2. Coral Growth on Submarine Cable after Twelve Years' Immersion.

been seriously damaged owing to the carelessness of a workman whilst trying to clear a drain near Reading in April of the present year. The man had driven his pick three-quarters of the way through the cable and the record of his handiwork as set forth on the exhibit card is supplemented by the statement that the removal of this particular fault cost about £100.

Oceanography Section.

In the oceanography section are a few exhibits which will attract the attention of the electrical student. Here are pieces of submarine cable which have been damaged by trawlers when fishing and by submarine disturbances in the Gulf of Mexico. One case contains interesting specimens of cable growths (Fig. 1), and another a large specimen of coral taken from a submarine cable after only twelve years' submersion (Fig. 2).

Further information concerning the damage done to telegraph cables by steam trawlers is contained in an interesting set of notes by Mr. Benest, which is issued by The India Rubber and Telegraph Works Company.

Incandescent Lamps.

The development of the modern incandescent lamp is demonstrated by Sir J. W. Swan's exhibit. The primitive type of electric lamp shown formed one of the exhibits in the famous patent action—Edison and Swan v. Holland (Woodhouse and Rawson). The identifying label is initialled by Sir Frederick Bramwell. This is the earliest lamp of the kind ever shown in public and is probably the oldest of its type with an authentic history. This is followed by early forms of carbon-filament lamps including the shortened type with parchment filament. The next stage shows squirted carbon filaments for low voltages, and later forms for the higher voltages. The latest development is shown in the form of the modern squirted metal-filament lamp. Here also are shown a number of filaments of various types and materials, the set including those made of drawn wire, bamboo, squirted granular carbon, parchment, squirted cellulose and lastly metal.

The Selenium Cell.

Dr. Shelford Bidwell exhibits some selenium cells. The electrical conductivity of these cells is greater in the light than in the dark. Two fine platinum wires, serving as electrodes, are wound close together upon a slip of mica, on one side of which a very thin film of the metal selenium is afterwards applied. Three later forms of these cells are also shown, the electrodes of which are wound upon flat grooved pieces of slate. Alongside is to be seen an original model of an apparatus illustrating a method of transmitting pictures by telegraph. The instrument was constructed in 1881, and shown in operation at the York meeting of the British Association. The image of one of the rude transparencies exhibited is projected by a lens upon a white surface at one end of a movable box inside of which is a selenium cell. In the middle of the surface is a small pinhole, which is caused to travel in a series of closely parallel lines over the projected image. The resistance of the selenium cell varies in correspondence with the illumination at every point traversed by the pinhole, and regulates the strength of the current supplied by two opposing batteries to a platinum stylus in the receiving instrument. The stylus traces a close spiral upon a rotating cylinder, around which is wrapped a piece of paper moistened with a solution

of potassium iodide. When the pinhole is in a dark portion of the picture the stylus makes a brown line on the paper; when it is in a light portion no mark is made: the broken spiral line constitutes the reproduced picture. The original reproductions are fugitive, those exhibited being copies. This system of telegraphic photography has never been applied to commercial purposes, but it is remarkable how closely it approaches in some ways the present-day systems which have lately been given much prominence. Of these the most important, in that it is in everyday practical use, is the method due to Prof. Korn.

Picture Transmission by Wire.

The Korn system of transmitting photographs by wire is shown in operation at the exhibition in the *Daily Mirror* building. In this system a photograph on a film of celluloid is placed round a glass drum which revolves in a spiral fashion, so that as it rotates it automatically rises vertically. All light is shut off from this drum by means of an outer box except for a very small hole in the front, on which the light from a Nernst lamp is concentrated by means of a condensing lens. It will thus be seen that the light, passing through the hole, will fall on consecutive tiny portions of the photograph, one after another, which are, of course, of different intensities. Thus the light which gets through the photographic film will be constantly varying in intensity.

Inside the revolving cylinder is a reflecting prism which reflects all the light passing through the film on to a selenium cell placed at the top of the box. Hence, as the photograph rotates. and the portions of it which intercept the source of light and the mirror vary in intensity, so the amount of light which is reflected from the prism on to the cell varies correspondingly. Now, the transmission wires or cable line between the transmitting and receiving instruments are joined up through this selenium cell, which offers considerable resistance to the electric current. But this resistance varies greatly according to the degree that the cell is illuminated; when a transparent portion of the film enables the prism to reflect much light on to the cell, the current passing through the latter is strong, and when a dark portion of the photograph allows only a little light to be reflected on to the cell, the current is weaker, and so on.

At the receiving station, therefore, one receives a current of constantly varying intensity. In the receiving instrument a lamp is placed at one end and at the other is fixed an opaque box containing an unexposed photographic film wrapped round a cylindrical drum, which is revolved again with a spiral motion, at, as nearly as possible, the same rate as that of the transmitting drum. The light from the lamp is concentrated by a lens upon a tiny hole in the box, so that a spot of light falls on the sensitive film as different consecutive portions of it come just behind the hole.

Between this aperture and the lamp is placed a powerful electromagnet, and suspended between the poles are two exceedingly fine silver wires, to which is attached a tiny piece of magnesium foil, so placed that when in its normal position it just throws a deep shadow over the hole in the box containing the receiving film, and thus protects it from the light.

Now these fine silver wires and the magnesium foil really constitute the suspended coil of a sensitive galvanometer, the foil taking the place of the usual reflecting mirror. Now the current of constantly varying strength which is received from the transmitting station passes through the suspended wires, and the foil is deflected, more or less according to the intensity of the current. As the foil is deflected, so the shadow it forms on the box will be more or less shifted from the little hole, and consequently the amount of light from the lamp which passes the foil and penetrates the hole, to act on the sensitive film behind it, will vary correspondingly.

When, therefore, the receptive film is developed we get a series of consecutive dots varying in intensity precisely according to the transparency of the corresponding tiny portions of the original photograph. A negative is obtained at the receiving station from a positive, and vice versa.

Although the above describes the principle on which this system is based, various devices are necessary to overcome faults, and to render the working of the apparatus more satisfactory. The chief of these is an extra selenium cell in the transmitter, whose properties are the reciprocals of those of the chief cell, and these neutralise one another, so that the change in electrical resistance

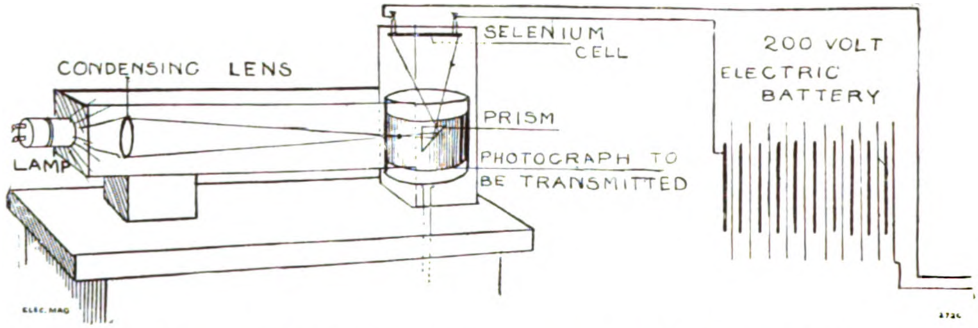


FIG. 3. DIAGRAM OF THE TRANSMITTING APPARATUS. KORN SYSTEM OF PICTURE TRANSMISSION.

with change in the light is made much more instantaneous and abrupt. Also the receiving drum revolves slightly quicker per revolution than the transmitting cylinder, and the moment the latter has completed one revolution, the receiving drum, which at the end of each revolution is automatically stopped by means of an exceedingly delicate form of relay, is released again by the latter, and the two once more begin a revolution together. This contrivance prevents any faulty working from causing a defect for more than one revolution; and as will be seen it is essential that the transmitting and receiving cylinders shall operate in synchronism.

The spiral line of light, always altering in intensity according to the light and shade in the photograph, causes the received pictures to appear furrowed, and they are indeed composed of a number of parallel lines varying in thickness and depth of tone, the effect of which is minimised by a suitable reduction in size for reproduction purposes. The Korn installation at *The Daily Mirror* pavilion is in charge of Mr. Thorne Baker, the engineer who is responsible for the working of the system at this end and to whom the author is indebted for his kindliness in demonstrating the operation of this interesting and valuable process.

Wireless Telegraphy.

The Marconi Company shows a large number of objects illustrating the rapid growth of their system of wireless telegraphy. Side by side with examples of the latest types of coherers are to be seen some of the first coherers made by Mr. Marconi while he was still unknown to fame, and when one notices that these latter, in spite of their antiquated appearance, are dated 1895—only thirteen years ago—one is impressed with the rapidity with which wireless telegraphy has been brought to its present state, to say nothing of its being already in daily commercial use. Moreover these exhibits remind us, much to our surprise, that we ourselves have seen the whole of the wonderful development which has marked the progress of a system likely to revolutionise the field of telegraphy.

There are also included the revolving spark

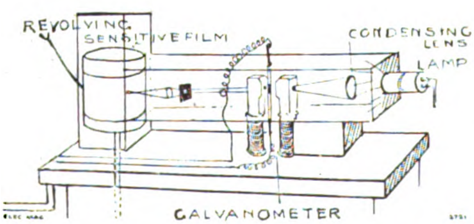


FIG. 4. DIAGRAM OF RECEIVING APPARATUS. KORN SYSTEM.

FIG. 5. PORTRAIT AS TRANSMITTED FROM PARIS TO LONDON BY THE KORN SYSTEM.

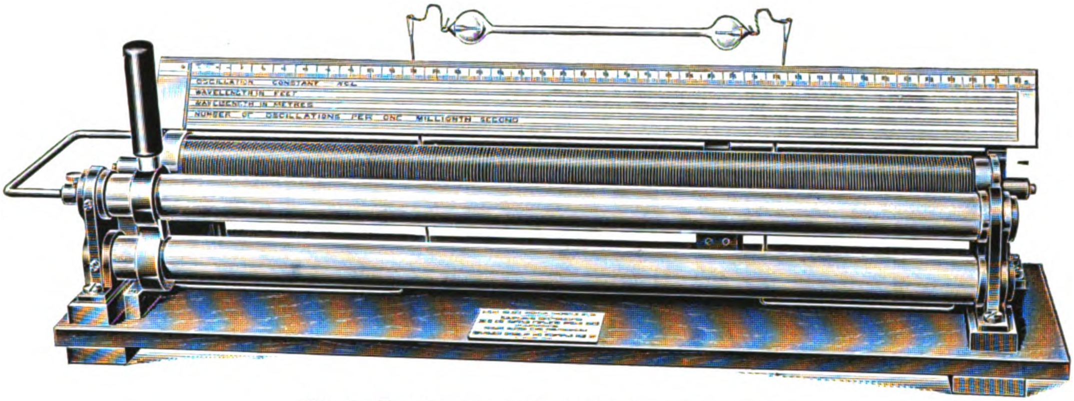


FIG. 6. THE CYMOMETER (ELECTRIC WAVE MEASURER).

discharger formerly used at Poldhu, 1902, the first transmitting jiggers and aerial tuning inductances; balloons and kites and some of the apparatus used on Signal Hill, St. John's, Newfoundland, for the first trans-atlantic reception in 1901. A number of models indicate the gradual improvement of the aerial from the early Hertz oscillator to the modern directional aerial, and one of them bears the label "Model of aerial with earth connection, illustrating Mr. Marconi's fundamental invention and the essential feature of all modern wireless telegraphy." Many of the pieces of apparatus displayed impress upon us the fact that quite important advancements are made in scientific knowledge with the aid of the crudest materials. Marconi, in his early investigations, made use of wine bottles and old cigar boxes, the former being employed in the making of the first transmitting jiggers, newspaper being the insulating substance, and the latter for the first magnetic detector.

On the screen at the back are a number of frames containing the actual tapes received when each new long-distance record was made.

As of further interest to students of wireless telegraphy it is to be noted that there is on view a complete installation for the Electromagnetic Induction System of Wireless Telegraphy as used between Lavernock and Flatholm by the G.P.O., in 1897.

The Cymometer.

In connection with the Marconi system an exhibit of exceeding interest is that of Dr. J. A. Fleming, F.R.S., who shows two forms of cymometers, instruments devised by him for measuring the length of the electric waves used in wireless telegraphy, and for other measurements in connection with radio-telegraphy. One type is the earliest form of instrument constructed, the

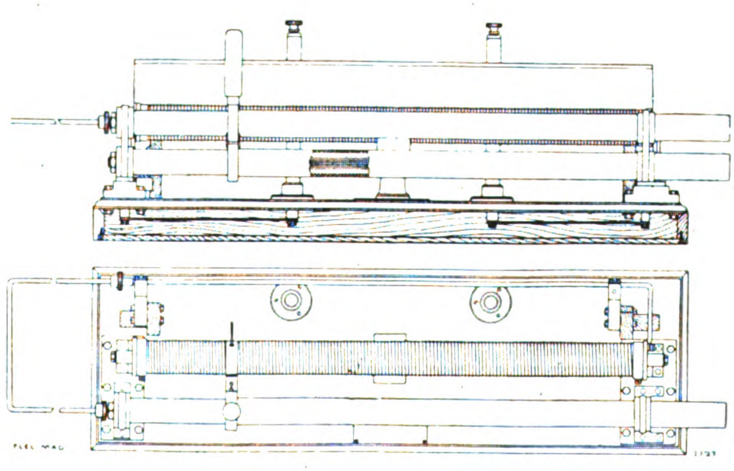


FIG. 7. DIAGRAMMATIC ELEVATION AND PLAN OF THE CYMOMETER.

other is the more recent and generally used form. It is a matter of great importance in practice with electric wave telegraphy to determine easily the length of the electric waves made use of, as well as the frequency of the oscillations in the antenna or aerial wire, and this can be done at once without the slightest skill by means of the direct-reading cymometer. The instrument consists of a sliding tube condenser which is joined in series with a variable inductance coil and with a copper bar, thus completing the circuit. This forms what is known as a closed oscillatory circuit, the capacity and inductance of which can be varied simultaneously and in the same proportion over certain limits by one movement of the handle shown at the left-hand side in Fig. 6.

If such a circuit is placed in contiguity to another circuit—for example, the antenna of a wireless telegraph transmitter in which high-frequency oscillations exist—these last tend to induce secondary electric oscillations in the cymometer, but the amplitude of these secondary oscillations is extremely small unless the circuit of the cymometer is tuned or adjusted to that of the primary circuit in which the oscillations are taking place. If, however, this adjustment is exactly made, then the primary oscillations create secondary oscillations in the cymometer circuit of great amplitude; in other words, set up a powerful secondary current in the cymometer circuit. This adjustment is effected by moving the handle, thus causing the tube or tubes which form one surface of the condenser to slide more or less off an ebonite tube which encloses other metallic tubes forming the second surface of the condenser, and at the same time inserts more or less of a spiral of wire into the circuit. The adjustment which is necessary to secure this precise tuning between the cymometer circuit and the circuit under test is recognized by the employment of a neon vacuum tube connected between the inner and outer surfaces of the sliding tube condenser. Neon is one of the rare gases contained in the atmosphere, and some years ago it was found by Dr. Fleming that a glass tube filled with rarefied neon constituted an extremely sensitive means of detecting high-frequency electric oscillations, as the tube glows with a brilliant orange light when the platinum terminals are connected to two points on the circuit in which such oscillations are taking place. Over the inductance spiral of the cymometer is placed a scale having four rows of graduations. One of these is marked Oscillation Constant; the next, Wave Lengths in Feet and Wave Lengths in Metres; and the fourth row, Number of Oscillations per one millionth of a second. As the handle is moved along, sliding a clutch which is attached to it over the inductance coil, a pointer fixed to the latter moves over this divided scale.

Fig 6 represents the instrument exhibited which is the most recent form, and Fig. 7 is a diagrammatic elevation and plan of the same. It can be used for wave lengths of between 200ft. and 3500ft.

Electric Wave Detector.

Amongst the most up-to-date instruments the splendid display of the Cambridge Scientific Instrument Co. is especially noteworthy, their beautifully finished productions being distributed throughout the majority of the sections in the Hall of Science. One of the large number of exhibits shown by this company is a Hertzian wave-detector designed by Mr. S. G. Brown.

In wireless telegraphy, if the distance between the sending and receiving stations is short, the currents induced in the receiving conductor may actually be of sufficiently high potential to cross a spark gap, and signals may thus be directly observed. But in practice, the distances are always too great for this method, so it becomes necessary to use some indirect method for

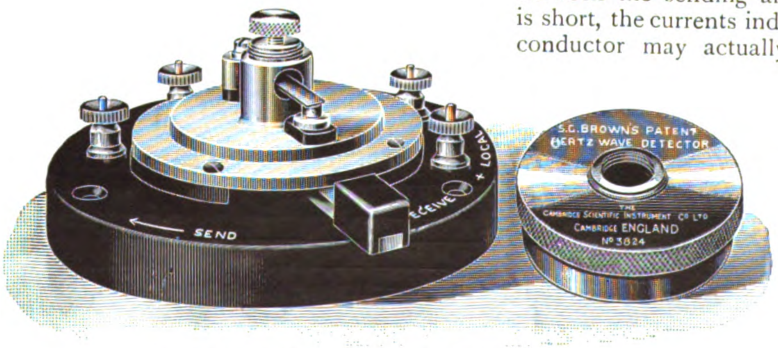


FIG. 8. THE BROWN HERTZIAN WAVE DETECTOR

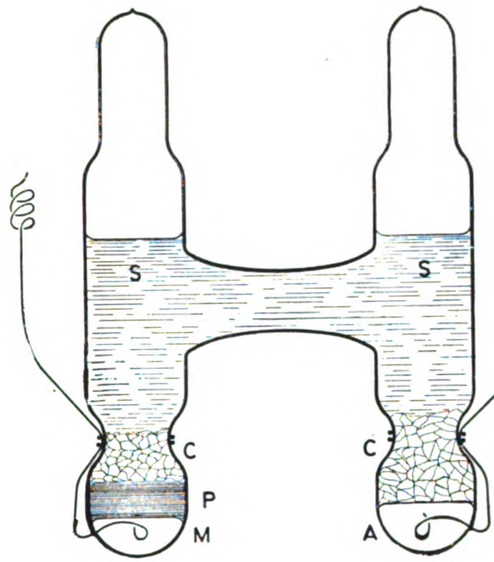


FIG. 9. WESTON TYPE OF CADMIUM CELL.

M = Mercury.
A = Cadmium Amalgam.
P = Paste of Mercurous Sulphate.
C = Cadmium Sulphate Crystals.
S = Saturated Solution of Cadmium Sulphate.

manifesting the existence of the induced currents, and this is best carried out by observing in a secondary or relay circuit some change induced by the received oscillations.

The essential part of the light and portable Brown detector is a small pellet of lead peroxide held between a plate of lead and another of platinum. This combination acts as an electrolytic cell in which the lead peroxide is the electrolyte and the lead and platinum plates are the electrodes.

If an external e.m.f., as for instance that of an accumulator cell, is impressed upon the detector so that a current flows from platinum to lead, the passage of that current will be partially opposed by the e.m.f. of the combination. A steady condition will be arrived at when the current flowing is due to the excess of the e.m.f. of the accumulator over that of the detector. This steady current may be made to give a deflection to a galvanometer needle.

If now oscillatory currents are made to pass through the detector, it will act as an electrolytic valve, the apparent back e.m.f. will increase, and this will be shown by a decrease in the galvanometer deflection. Fig. 8 is an illustration of the instrument, the brass cover being removed.

The properties of this detector are used as follows:—An accumulator cell is arranged to pass a current through a galvanometer and the detector in series. The receiving conductors are then connected so that any currents induced in them pass through the detector, the existence of such currents being shown by a diminution in the galvanometer deflection. A two-way switch is arranged with the detector, by means of which the receiving and sending circuits are made or broken as desired, and the detector is completely shielded by metal when the station is being used to send messages.

Cadmium Cells.

In view of the present interest in the definition and selection of absolute electrical standards and the prominence which the cadmium cell is receiving as a possible substitute for the Clark cell as the standard of e.m.f., the cadmium cells shown will no doubt be objects of interest. The well-known form of cell originally suggested by Mr. Weston possesses the great merit of a practically negligible temperature coefficient over the ranges of temperature usually found in a laboratory. Fig. 9 represents diagrammatically the construction of the H-form suggested by Lord Rayleigh, of which type there are a number exhibited.

This form of construction prevents the mercurous sulphate from attacking the amalgam, and also renders the cell more portable.

Electric Pyrometry.

During the last few years great progress has been made in the measurement of temperature by electrical means. Until quite recently the temperature of a retort or furnace was gauged by the eye of the most experienced workman. When this particular individual left, the works were, for the time being, more or less paralysed. In many processes it is important that the temperature should be known within two or three degrees. In annealing, for instance, a rise of comparatively a few degrees above the correct temperature may spoil a large batch of stampings or forgings. The economy of the steam engine and boiler plant is one of the great problems the engineer has to face, and, therefore, the measurement of the

temperature at various points, such as the boiler feed and flues, is of the utmost importance.

The disadvantages of glass thermometers for commercial work are well known. The risk of breakage, the fact that they can only be placed in positions in which they can be easily read, and their unsuitability for the measurement of high temperatures, have all led to the extended use of the new forms of electrical resistance thermometers. Various patterns are to be seen in the Cambridge Company's collection. A sectional illustration of a type suitable for general test work, boiler flues, &c., and which will indicate temperatures up to 2192deg. F. (1200 deg. C.) is shown in Fig. 10.

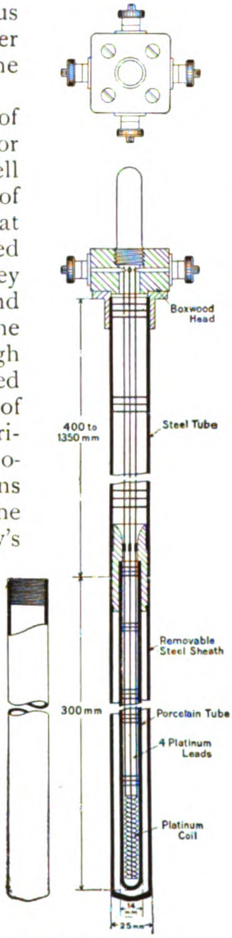


Fig. 10. Electric Thermometer.

The essential part of these instruments is a fine platinum wire which is wound on a mica frame, and whose resistance becomes greater as its temperature rises. This wire is called the bulb, and is contained in the lower 4in. of the projecting tube. It is connected by stouter wires to an indicator or recorder. For protection against fumes and mechanical damage the bulb is enclosed in a tube of porcelain, steel, or brass, according to circumstances. An arrangement of compensating leads eliminates all effects due to the temperature of the connecting wires. The compensating leads permit of the thermometers being placed at considerable distances from the instrument actually employed to read the temperature. Thus there are installed at the Royal Arsenal, Woolwich, some resistance thermometers in the experimental explosives huts, and the indicators for reading these thermometers are placed in an engine-room three-quarters of a mile away. Two instruments are shown which are used for obtaining the temperature by means of the resistance thermometer. They are the Whipple patent temperature indicator for direct reading, and, for recording purposes, the Callendar patent recorder.

Fig. 12 illustrates a resistance thermometer connected to a Whipple temperature indicator. By depressing the contact key F, and by turning the milled head H, the resistance of the indicator is made to equal that of the thermometer, the galvanometer needle at B showing when balance is obtained. The required temperature can at once be read off on the scale at A. By means of this instrument any workman, without electrical knowledge, can ascertain the temperature of his furnace or source of heat in two or three minutes.

The Callendar electric recorder is to be seen amongst the instruments exhibited by the Meteorological Office. When a resistance thermometer is connected to a recorder, the resistance of the former is automatically balanced by resistances in the latter. When the thermometer temperature varies the balance of resistances is disturbed and the automatic restoration of the balance causes the pen to travel across the paper and register the temperature When the balance is disturbed the deflection of the galvano-

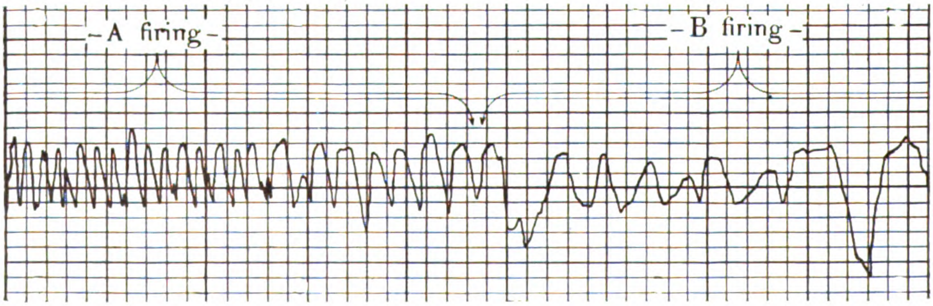


Fig. 11. Diagram of Furnace Temperatures by the Callendar Electric Recorder.

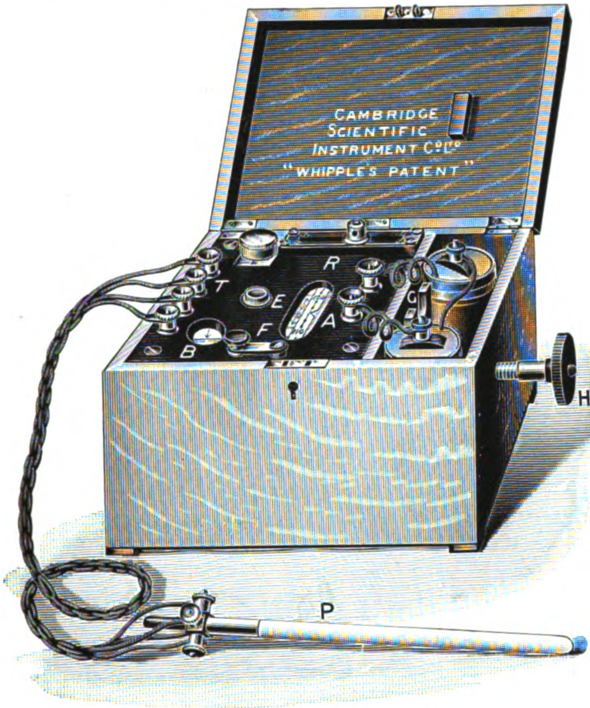


FIG. 12. THE WHIPPLE TEMPERATURE INDICATOR.

tric furnace of the resistance type. In the electric resistance thermometers mentioned above there is some part—the sensitive or receptive part—which is made to acquire a temperature identical with the temperature to be measured. In the measurement of furnace-temperatures, for example, radiation pyrometers are the only pyrometers or thermometers which are entirely outside the furnace. As is well known, it is difficult to construct anything of solid material which can be maintained for prolonged periods at a high temperature without its suffering some permanent or sub-permanent change in its physical properties, and as the tests ascend higher in the temperature scale, the difficulties increase in a quite disproportionate degree. A further aggravation of the trouble is to be found in the chemical activities of furnace products and furnace gases, which in some cases render difficult

meter completes a circuit, which allows a motor clock to pull the pen along until the balance is restored. A continuous record of the temperature is thus obtained.

One of these instruments is illustrated in Fig. 13.

A record of the temperature in an annealing furnace obtained with a resistance thermometer and Callendar's patent recorder is shown in Fig. 11.

Included in the splendid collection of exhibits organized by the National Physical Laboratory will be found specimens of Féry radiation and absorption pyrometers which are shown as for actual use in conjunction with an elec-

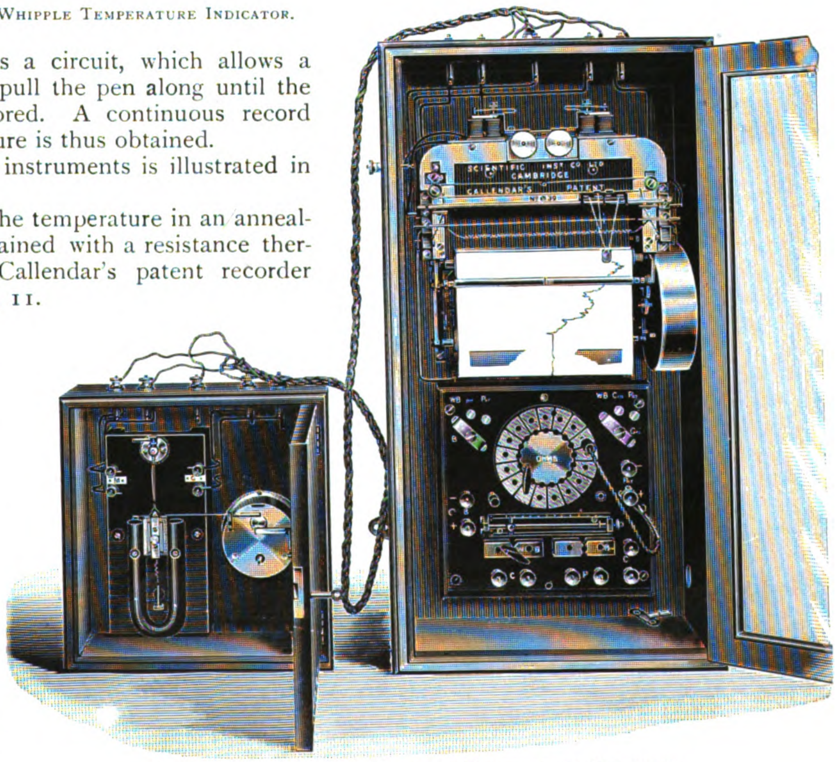


FIG. 13. THE CALLENDAR ELECTRIC TEMPERATURE RECORDER.

the adequate protection of the resistance-wire or thermo-couple.

With the radiation pyrometers invented by M. Féry, Professor of Physics at the Ecole de Physique et de Chimie, Paris, these difficulties are not encountered, the instruments being of course placed at some distance from the furnace, while no part of them is raised above the air temperature by more than 80deg. C. The radiation which emanates from a hot body or which passes out through an observation hole in the wall of a furnace, falls upon a concave mirror and is thus brought to a focus. In this focus is a thermo-electric couple whose temperature is raised by the radiation falling upon it, and the hotter the furnace the greater the rise of temperature of the couple. The complete instrument consists of a telescope and galvanometer; fixed within the telescope, and on its optic axis is the junction of a copper-constantan thermo-couple arranged in the form of a cross. The terminals of the thermo-couple are connected by leads to the galvanometer. The e.m.f. which is generated when radiant heat is focussed on the couple is thus measured by the sensitive galvanometer, whose scale is divided and figured so as to read temperatures directly. The radiation pyrometer shown works over the range 600deg. C. to 2100deg. C. The other instrument exhibited in use is the absorption pyrometer, which has been found very useful for measuring the temperature of incandescent filaments and other extremely hot but small bodies.

Other Interesting Exhibits.

Numerous other types of instruments may be seen devoted to a large range of purposes: oscillographs of the latest high-tension, oil-bath type, for recording the simultaneous changes of P.D. and current on making and breaking an inductive circuit, the charge and discharge curves of condensers, the changes in P.D. and current in the armature coils of a dynamo, and even the very rapid variations of P.D. and current which occur when the direct-current arc hisses; galvanometers, such as the Einthoven "string" type, which, used in conjunction with a photographic recording apparatus, will record alternation or pulsating currents of very small magnitude: or the Duddell thermo-galvanometer, which, having practically no self-induction or capacity, can be used on a circuit of any frequency even up to 120,000 vibrations per second, and which will readily measure currents as small as 20 micro-amperes; or a Grassot fluxmeter, which is a suspended coil ballistic instrument designed for use in the measurement of the strength of a magnetic field, the pole strength and distribution of magnetism in a bar-magnet and permeability and hysteresis.

Not less interesting are the rest of the exhibits in this section, but space does not permit of more than a mere mention of the electric micrometer of Dr. Shaw, the many magnifying spring instruments of Profs. Ayrton and Perry, the bolometer and Kelvin ampere balance shown by the Davy-Faraday Research Laboratory in the Chemical Section, the electrical resistance furnace of the type used for the determination of recalescence curves, and the various patterns of resistance bridges, potentiometers, and standard coils.

On the occasion of our first visit to the Science Hall, we were greatly surprised that the electrical science exhibits are not grouped together in one section. It is a somewhat disappointing fact that little or no trouble has been taken to combine the different electrical exhibits one with another. This is no doubt the result of the exhibitors' lack of acquaintance with each other, and is also due to the overlapping of the different branches of science.

For the student and the expert there is nothing that is not of exceeding interest, and for a detailed inspection repeated visits will, of course, be necessary, but the non-technical visitor will find that there is much to appeal to the lay mind. It will be observed that only British science is represented in the Franco-British Exhibition, and it is much to be regretted that, considering the eminence which the French exhibits have attained in other directions, it was not found possible to organize a French science section.

NOTEWORTHY EXHIBITS OF ELECTRICAL AND GENERAL ENGINEERING INTEREST.

Power-generating Plant.

As one would expect, the most prominent and popular of the several electric power exhibits are those connected with the general power supply of the exhibition. These include a complete gas-power station, having a 2000h.p. Mond producer, supplying a large Westinghouse gas-engine set, and a steam-driven plant consisting of a battery of three Babcock & Wilcox boilers, operating a Parsons turbo-generator. These two equipments work in parallel day-by-day upon load under actual industrial conditions, and as such receive the greatest attention of visiting engineers.

Babcock & Wilcox, Ltd.

The whole of the boiler-house plant providing the power for the Parsons turbine set generating electricity for use in connection with the Exhibition supply has been provided by Messrs. Babcock & Wilcox, Ltd. The plant consists of three of their well-known patent water-tube boilers, of which it is said some 6,800,000 horse-power of the land type and 1,400,000 horse-power of the marine type are now in use. Each of the boilers installed at the Exhibition has 3140 square feet heating surface, and is capable of evaporating 10,000lb. of water per hour. They are constructed for a working pressure of 160lb. per square inch, and are complete with all the usual mountings and fittings, two of them being set together in one battery, whilst the third stands by itself.

These boilers are essentially composed of three elements, each connected with the other, and in each of which the process of steam-raising is separately carried on: (*a*) A series of inclined water tubes over the furnace, in which the water, being divided into small columns, is quickly raised to a high temperature, and rises through vertical connecting boxes or headers at the front end into (*b*) horizontal steam and water drums, where the steam separates from the water. The water remaining returns through vertical tubes at the back into the inclined water tubes, where it is subjected to the action of the fire, and again passes into the steam and water drum; thus a continuous and rapid circulation is kept up, and a uniform temperature maintained throughout the boiler; (*c*) a mud collector, attached to the lowest point of the inclined water tubes, into which any matter held in suspension is to a large extent precipitated by reason of its greater specific gravity, during the passage of the water through the vertical tubes and rear headers.

Superheaters.

Each of the boilers is fitted with a Babcock & Wilcox patent steam superheater, having 427 square feet heating surface, and capable of imparting from 100deg. to 120deg. F. of superheat to the steam generated. The

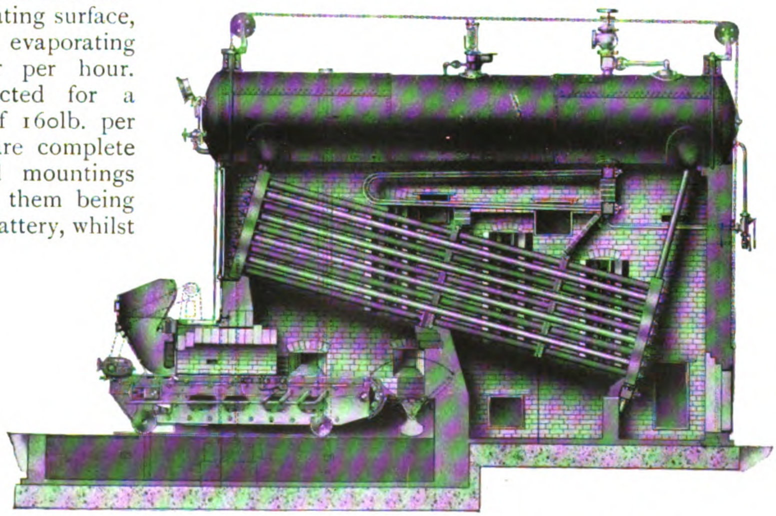


FIG. 1. BABCOCK & WILCOX BOILER, WITH INTEGRAL SUPERHEATER AND CHAIN-GRATE STOKER.

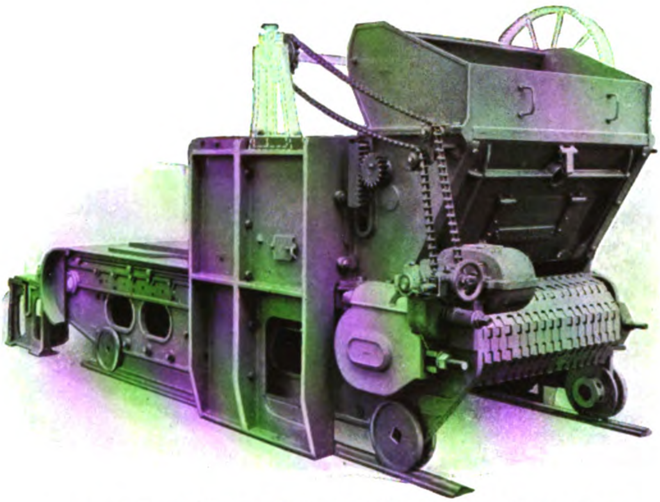


FIG. 2. FRONT VIEW OF BABCOCK & WILCOX CHAIN-GRATE STOKER.

superheaters consist of a number of solid drawn steel tubes bent into "U" form, and expanded at each end into wrought steel boxes or manifolds. The steam from the boiler, entering the upper manifold box, divides amongst the "U" tubes, and during its passage through them becomes superheated or raised to a higher temperature than previously.

Mechanical Stokers.

Each boiler is also fitted with one of the makers' latest design of mechanical chain-grate stoker, of which nearly 3000 are now in use. The grate consists of an endless chain of short grate bars, which are linked together, and pass over drums at the front and rear end of the stoker. The coal is fed over the whole width of the grate, and its depth regulated by a door which can be raised or lowered by gearing. The travel of the grate carries the fuel very slowly towards the back of the stoker; on arriving there the fuel is exhausted and only ash and clinker remain, which fall over into an ashpit. The power for rotating the grate continuously is transmitted through a patent gear-box, by means of which four different speeds can be given to the chain. Comprised also in the gear-box is an automatic clutch, which slips if any obstruction prevents the free rotation of the grate.

Each stoker is fitted with an arrangement of vanes for cutting off the air supply to a portion of the grate during periods of light

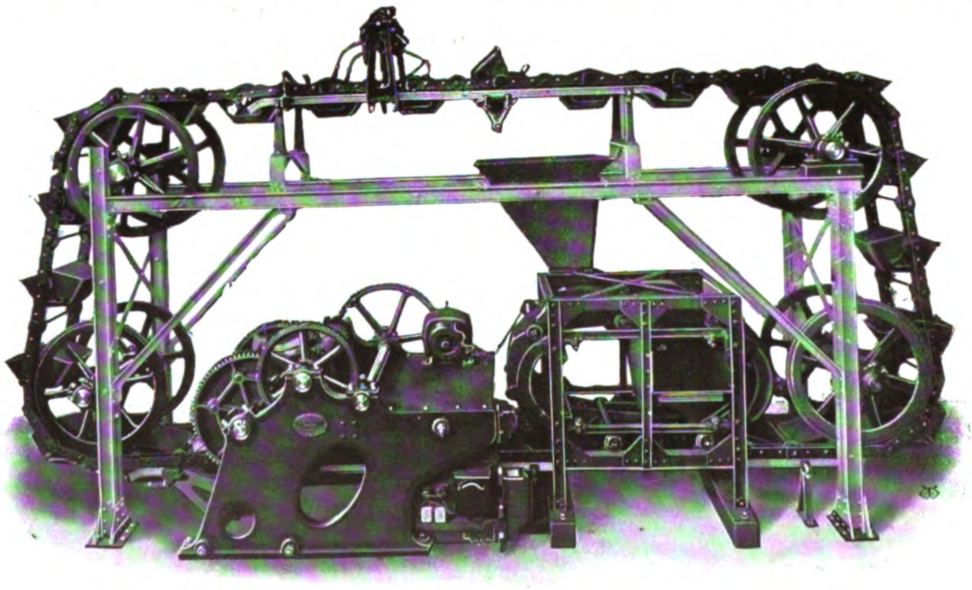


FIG. 3. MODEL SHOWING THE COMPLETE BABCOCK & WILCOX CONVEYOR EQUIPMENT.

load, thus enabling the maximum efficiency to be maintained under such conditions of working. No firing tools are required, as the action of the grate is entirely self-cleaning, and the fire does not need to be touched in any way. The power for driving the stokers is supplied by a small steam engine of Messrs. Reader & Co.'s make.

Boiler Plant Auxiliaries.

The wrought-iron chimney has also been supplied by Messrs. Babcock & Wilcox, but as it was desirable to keep this as low as possible, two induced draught fans, constructed by Messrs. Musgrave & Co., Ltd., St. Ann's Iron Works, Belfast, were installed, one fan being actuated by an electric motor, and the other by a direct-coupled steam engine.

The water is fed into the boilers by two feed pumps, each of suitable size for feeding two boilers, one pump being left as spare; these are made by Messrs. J. P. Hall & Sons, Ltd., Peterborough.

On its way to the boilers the feed water passes through one of Messrs. Lassen & Hjort's patent automatic water-softeners, which Messrs. Babcock & Wilcox handle under licence, thus eliminating the scale-forming matter from the water before it enters the boilers, a pump lifting the water to the softener.

The whole of the steam, feed and exhaust piping is also of Messrs. Babcock & Wilcox's manufacture, the steam piping being of solid drawn steel with the flanges riveted on in the case of the larger pipes, and screwed on in the case of the smaller pipes.

The steam trap is of Messrs. Geipel & Lange's make. The water meter is by Messrs. Kent & Co., and the whole of the lagging was supplied by Messrs. Hobdell, Way, & Co.

Messrs. Babcock & Wilcox also occupy a stand inside the Machinery Hall, and here are shown a number of interesting specimens and models, including a marine boiler as used in the Mercantile Marine, having a heating surface of 420 square feet, and a grate surface of 18 square feet, constructed for 200lb. per square inch working pressure; a coal conveyor exactly as shown in the illustration Fig. 3; a model of their standard land-type boiler fitted with superheater and chain-grate stoker, as illustrated on the previous page, Fig. 2, and as already described; a model of the Lassen & Hjort water-softener. In addition to these there are also exhibited a collection of steam piping, and a number of photographs showing various typical boiler installations.

C. A. Parsons & Co.

Turbo-generator.

Messrs. C. A. Parsons & Co. have installed in the British section of the Machinery Hall the 1800kw. turbo-generator, which is running continuously for the purpose of generating current in connection with the lighting and power supply of the Exhibition. This fine generating set attracts widespread interest and forms one of the most popular features of the machinery section. It is of the makers' standard type, embodying all their latest improvements, and may be taken as an up-to-date example of the Parsons' steam turbine generator, as manufactured by them at their works, Newcastle-on-Tyne.

The plant consists of a steam turbine arranged for driving two dynamos in tandem, at a speed of 1800r.p.m. The turbine is of their latest improved parallel type, adapted for the full range of expansion from the boiler pressure to the condenser pressure, and is also designed to work non-condensing; it is suitable for and is working upon a steam pressure at the boiler of 150lb. above atmosphere, and superheated steam. It is also fitted with mechanical governor, arranged for a speed regulation within 2½ per cent. permanent and 5 per cent. momentary variation when full load is thrown suddenly on or off.

The dynamos are of the latest construction fitted with the Parsons' patented compensated windings, which enables sparkless commutation to be obtained at all loads without moving the brushes. Each dynamo is capable of giving an output of 900kw. at 460-560 volts, and will also maintain an overload of 25 per cent. for two hours, and 50 per cent. momentarily.

The Power Gas Corporation, Ltd.

2000h.p. Mond Gas Plant.

This plant, which provides the gas supply for the large Westinghouse gas-driven generating set used in connection with the supply of power for the machinery in the machinery hall, consists of two of the well-known Mond producers, each 7ft.

2000H.P. MOND GAS PRODUCER PLANT.

internal diameter; one patent mechanical washer; one gas-cooling tower; two centrifugal cleaners; two scrubbers, and a governor.

The coal to be gasified is delivered by means of an elevator into the bunker above each producer, which in turn delivers the fuel into a cast-iron charging hopper at the top of the producer. The fuel on entering the producer from the charging hopper goes into a cylindrical bell, which has for its chief object the maintaining of a constant level of fuel. The gas producer consists of two cylindrical steel shells, one within the other, the inner shell being lined with firebrick, the annular space between them forming an air jacket, in which the air and steam blast is superheated on its way to the space beneath the grate, which consists of specially-designed fire-bars set radially in the form of an inverted cone.

The producer is of the water-luted type, with lutes all round, and is so constructed that ashes may be removed at all times without interruption of the operation of the producer. In other words, the producer is absolutely continuous in operation. The air blast is supplied by a Roots blower.

The gas leaving the producer passes into a rectangular steel washer, in which it is brought into intimate contact with water sprayed up into the form of rain by quickly-revolving dashers or paddles. By this means the gas is here freed from dust and partially from tar and is at the same time considerably cooled down. On leaving the washer the gas enters at the bottom of a gas-cooling tower packed with short earthenware tubes, which effectually distribute over the whole area of the tower the water which is supplied at the top. The gas passes upwards and on its way comes into intimate contact with the water trickling down. In this tower the gas is much cooled and a large amount of tar is removed. The gas then passes into a pair of specially-designed centrifugal cleaners, into which a small amount of water is introduced. Herein the gas is still further cooled down and freed from tar, and when it leaves this apparatus only contains a small trace of tarry matter, which is removed as the gas passes through the scrubbers, which are rectangular steel boxes fitted with a number of trays, on which are placed simple wood planings or shavings and sawdust. The gas then passes in a thoroughly clean state to the gas engine, which is of the vertical Westinghouse type described elsewhere.

One of the chief points of advantage in this type of plant is that a very cheap fuel can be used, whereas in all other types of plant it is necessary to either use anthracite or a special grade of nut fuel.

These plants are very simple in operation and are so designed and constructed that a minimum amount of labour is required for their operation, the gas production being automatically controlled to give only the amount required by the gas engine even under variable load, thus preventing all waste of gas. The stand-by losses are extremely small, and after remaining idle for a fortnight or more the producer may be brought into proper working condition in about twenty minutes; while after ordinary night stoppages it is only necessary to turn on the blast for about five minutes previous to the gas being actually required at the engines.

The British Westinghouse Electric and Manufacturing Company, Ltd.

Gas-electric Generators.

The British Westinghouse Company are, themselves, not exhibiting in the proper sense of the term at the above exhibition, but they have supplied plant and apparatus of various kinds to several of the exhibitors.

The most prominent of these is, of course, the 500kw. gas-engine generating set supplied to the Exhibition authorities for lighting the Main Machinery Hall, and for operating machinery therein. This set operates in parallel with the Parsons steam turbine-generator set and consists of a 750b.h.p. three-crank six-cylinder gas engine of the Westinghouse vertical tandem type recently introduced on the market, direct-coupled to a 500kw. Westinghouse direct-current generator. The gas engine operates on producer gas, supplied from the Mond gas producer provided by the Power Gas Corporation and described above. The cooling tower for the water in connection with this engine was supplied by Messrs. Jarvis Bros., Middlesbrough.

For generating electricity for use in their pavilion the Canadian Government have erected two gas-engine generating sets, each of 130kw. capacity. These engines are of the same type as those supplied for the Machinery Hall, and each is direct-connected to a 130kw. direct-current generator. The engines are run on ordinary illuminating gas. The Canadian Government have also installed in their pavilion some forty-eight direct-current and alternate-current Westinghouse standard pattern flame-arc lamps.

The Australian Pavilion is also lighted from separate machinery installed therein, and consisting of two gas-engine generating sets, one of 100kw. and the other of 130kw. capacity. The former is a single-crank two-cylinder, and the latter a three-crank six-cylinder engine, both being of the Westinghouse new vertical tandem type, and

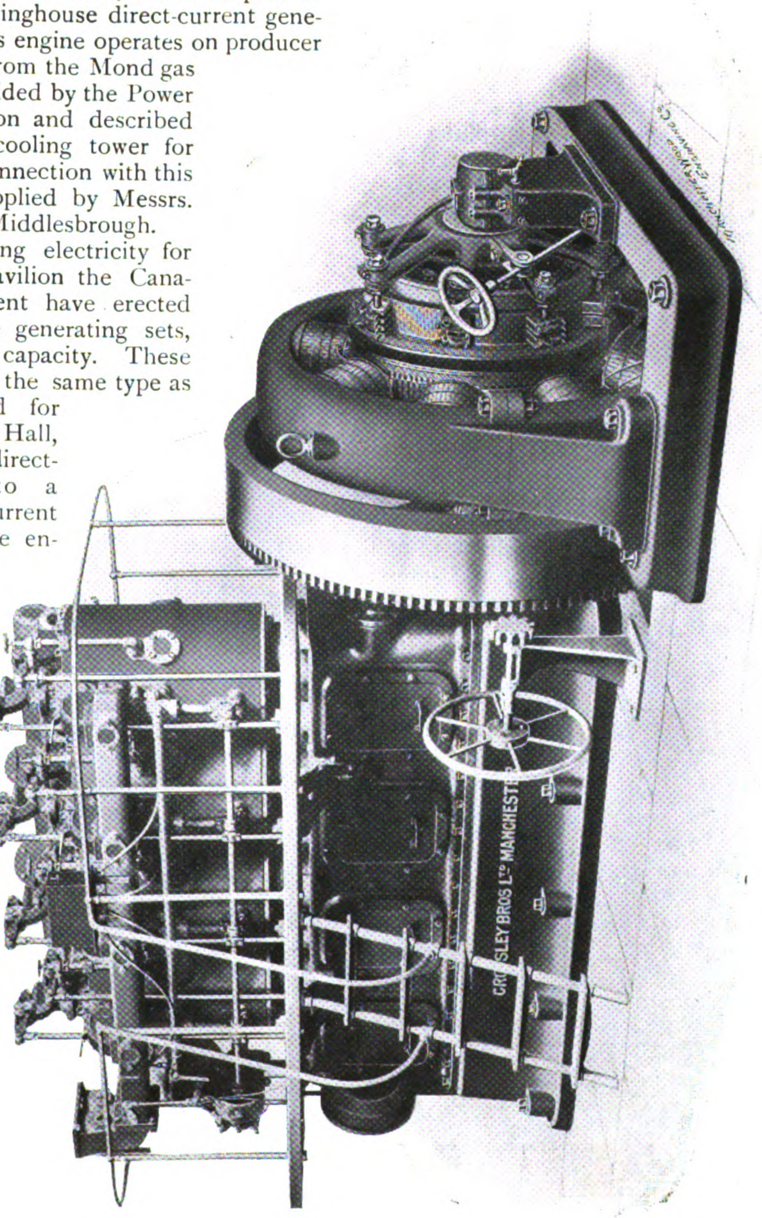


Fig. 1. Four-Cylinder Crossley Gas Engine, direct-coupled to G.E.C. Direct-Current Generator.

both being adjusted for operating on ordinary towns' gas.

Crossley Bros., Ltd.

This well-known firm has quite a representative exhibit situated near the main entrance of the Machinery Hall. The following engines are shown, and in addition to them there is also a suction gas plant in operation.

- 14 by 16 $^4/_c$ vertical gas engine and dynamo 125kw.
- "O" type horizontal gas engine.
- "NNN" type horizontal naphtha engine.
- "CV1" type vertical engine with dynamo.
- "CV2" type vertical marine engine with propeller.
- "HH" type horizontal oil engine.
- "L" type horizontal gas engine and air compressor.
- Four-cylinder motor-car engine.

Suction Gas-Electric Plant.

The suction gas plant, Crossley No. 8 type, generates gas from anthracite coal for the four-cylinder vertical gas engine, which is direct-coupled to a continuous-current dynamo, built by the General Electric Company (Fig. 1). The full working load of the combined plant is 125kw., the pressure being 220 volts and the speed 250r.p.m.

The engine is started by compressed air obtained from a compressor combined with a Crossley "L" type gas engine. The air is stored in three steel receivers at a pressure of 180lb. per square inch, and as the pressure only falls 5lb. or 10lb. each time of starting, the compressor is not often required. A pressure of 80lb. in the receivers is sufficient to start the engine.

Forced lubrication is fitted throughout the main moving parts of the engine, two valveless oil pumps situated within the engine baseplate performing this work. All the oil passes through gauze filters before entering the pumps. In addition to the suction gas supply an alternative arrangement is fitted for enabling the engine to work with towns' gas, and the change from the one to the other may be made without stopping the engine. This important feature is made possible by means of the Crossley patent governing valve with which the engine is fitted.

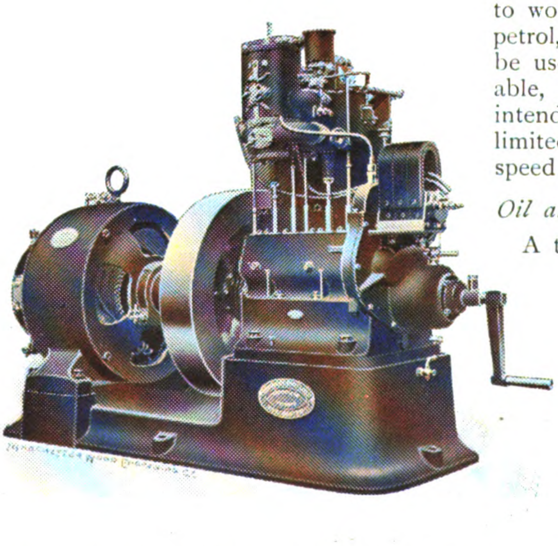


Fig. 2. Crossley High-Speed Gas-Electric Generator.

High-speed Gas-Electric Generating Set.

Another gas engine shown is of the vertical high-speed class. This engine (Fig. 2), the "CV1" type, develops $5\frac{1}{2}$b.h.p. with towns' gas when running at 700r.p.m. and is coupled direct to a dynamo, the combination being mounted on a substantial cast-iron bedplate. The weight of the complete set is $12\frac{1}{2}$cwt. This engine is provided with loose renewable cylinder liners and adjustable bearings. This class of engine is supplied with either one, two, three, or four cylinders to work on either towns' gas, producer gas, petrol, petroleum, benzol, or alcohol, and to be used either for stationary, marine, portable, or electric lighting purposes. It is intended especially for use when either a limited space is available, or where a high-speed or a light weight is essential.

Oil and Petrol Engines.

A two-cylinder marine petrol engine of similar type to the foregoing type, "CV2," is also shown coupled to a reversible propeller and intended for use in a launch or similar type of vessel. Two of the firm's horizontal oil engines are shown also; one has a capacity of 1b.h.p. at 400 revs. and the other gives an output of $6\frac{1}{2}$b.h.p. at 280 r.p.m. The latter type of engine, "NNN," represents a class which is rapidly gaining favour, owing to its ability to work without

alteration with either the ordinary petroleum oils or with crude oils. No lamp is used except for starting purposes. Included also in the exhibit is a 40h.p. petrol engine, representing a type used upon the Crossley motor car.

W. H. Allen, Son, & Co., Ltd., Bedford.

This exhibit gives a very admirable idea of the various types of machinery manufactured by Messrs. Allen at their works in Bedford. Their well-known high-speed enclosed forced lubrication engines are represented by two examples, one a three-cylinder compound engine, and the other a two cylinder.

Three-cylinder Compound Engine.

This engine, Fig. 1, is capable of developing 450b.h.p. when running at a speed of 400r.p.m., and has one high-pressure cylinder 16in. in diameter and two low-pressure cylinders each 18in. in diameter, with a stroke in each case of 10in.

The main features of the construction of this engine are as follow :—The cylinders are cast in one with the distance piece, and are of a special mixture of hard close-grained cast-iron. The three cylinders are completely isolated from each other in order that the correct distance between their centres may be preserved at all temperatures, and stand upon a massive and neatly designed trunk, which completely encloses the working parts of the engine, and which also carries the slides for the main crossheads. The trunk is provided with three doors in front which give easy access to the working parts. The distance piece between the cylinders and the trunk is provided with openings which permit of easy access to the piston and valve rod

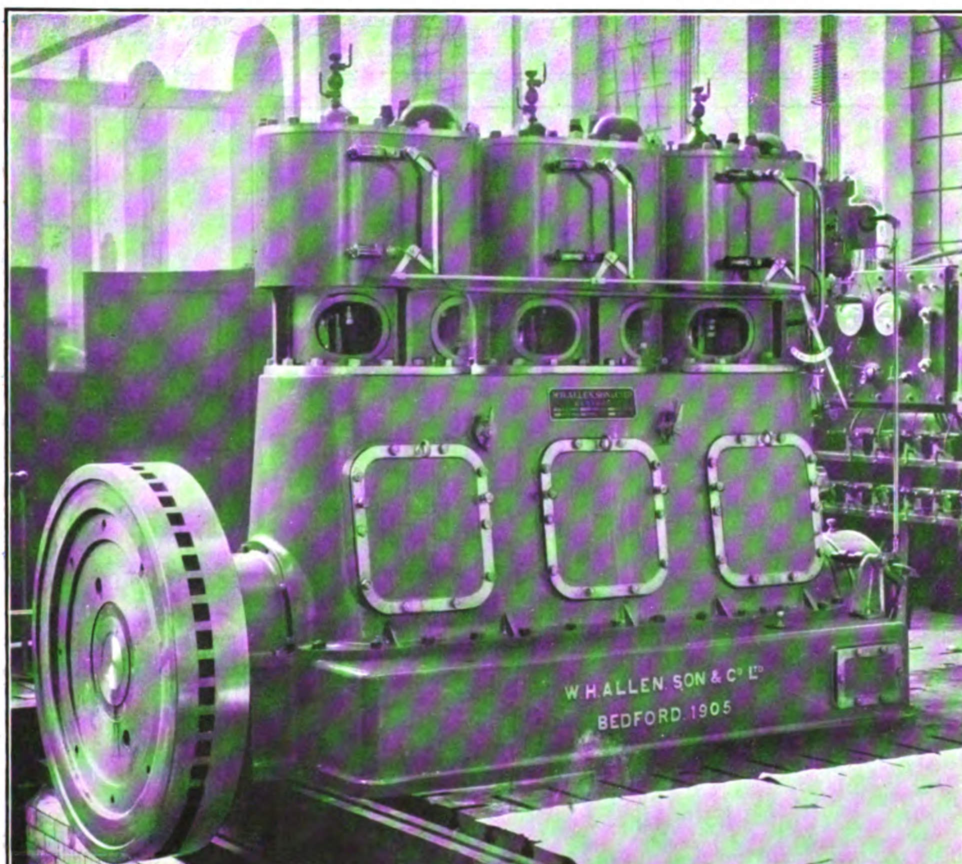


FIG. 1. ALLEN THREE-CYLINDER COMPOUND ENGINE.

glands. The apertures through which the piston and valve rods pass into the trunk are fitted with a special form of bush which effectively prevents oil from passing up into the cylinders, and also prevents water from entering the crank-chamber. The whole trunk and cylinders complete stand upon a massive cast-iron bedplate of box form which contains a reservoir into which the oil drains, and from which it is supplied at a pressure of 15lb. per square inch to all the working parts by means of a small valveless force pump, driven from one of the eccentrics of the engine. The high-pressure piston is of cast iron, of the solid block type, and is fitted with a solid packing ring of rectangular section. The low-pressure pistons are both of cast steel and conical in form, and are fitted with Rowans packing rings. All three pistons are of equal weight, and the connecting rods and piston rods being all identical, the weights on all three cranks are thus equalized. The cranks are set at equal angles of 120deg., a very satisfactory balance being thus ensured, the resultant vertical and horizontal forces respectively being practically eliminated, there remaining only two comparatively small unbalanced couples respectively in vertical and horizontal planes. The piston valves are of the solid type without rings, and take steam on the inside edges, thereby reducing the pressure on the glands, as compared with valves taking steam on the outer edges, and are driven independently through three eccentrics on the crank-shaft. The two low-pressure eccentrics are forged solid with the shaft, and the high-pressure eccentric is of forged steel keyed on. The crank-shaft, piston rods, valve rods, connection rods, and eccentric rods are all of the best open-hearth steel. The whole of the bearings throughout, with the exception of the crosshead bearings, which are of gun-metal, are lined with white-metal, and are supplied with oil under pressure from the force pump referred to above. The governor is of the Company's standard crank-shaft type, the centrifugal force of the weights being carried direct by the main springs without transmission through any working joints, the apparatus thus being almost entirely free from friction. The governor operates a double-beat throttle valve of

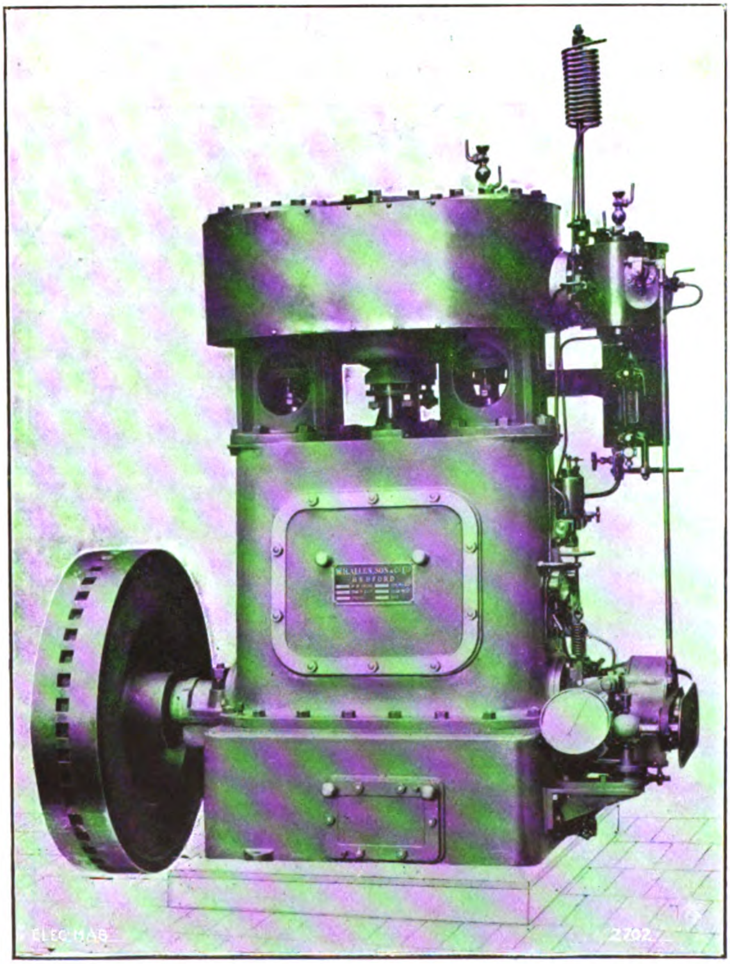


Fig. 2. Allen Two-Cylinder Compound Engine.

special design placed between the stop-valve and the engine, the spindle entering the valve box through a special pattern bush, which obviates the use of any packing whatever, and is consequently exceedingly free in its movement. With this type of governor the makers normally obtain governing within a total range of 2 per cent., and hand regulation is usually provided, enabling a variation in the steady speed to be obtained of about 5 per cent. above or below the normal. The flywheel is of the solid disc pattern and is forced on to the end of the crank-shaft and securely keyed. The face of the nave of the flywheel is accurately trued up to form the coupling for the dynamo. The cylinder volumes and the points of cut-off in each cylinder are carefully adjusted so as to produce as nearly as possible an equal distribution of power on all three cranks, thus reducing irregularities in the turning moment to a minimum. The cylinders, steam stop-valve, governor valve, and steam separator are all lagged with asbestos non-conducting composition laid on under steam, and are neatly covered with blue planished sheet steel, the whole presenting a very neat appearance.

Two-cylinder Compound Engine.

The two-cylinder compound engine, Fig. 2, is of the makers' standard type, capable of developing 220b.h.p. when running at a speed of 450r.p.m., and has two cylinders — the high-pressure being $13\frac{1}{2}$in. in diameter and the low-pressure 19in. in diameter with a stroke of 8in. The details of the design of this engine have much in common with those of the engine just described, with the exception of the cylinders, which are cast together with their valve chests in one piece. The two valves are also driven from one eccentric, the valve rods being connected to a substantial steel cross-bar within the trunk of the engine, the high-pressure valve receiving steam at the centre and exhausting over the outer edges, and the low-pressure valve receiving steam on the outer edges and exhausting from the centre. The cranks in this case are set opposite to each other, with a view to obtaining a good balance, and the two valve chests are placed on either side of the centre line of the engine, thus enabling the cylinders to be placed as close together as possible, thereby reducing the unbalanced couple to a minimum.

Condensing Plant.

Messrs. Allen's condensing equipment is well represented by two of their standard

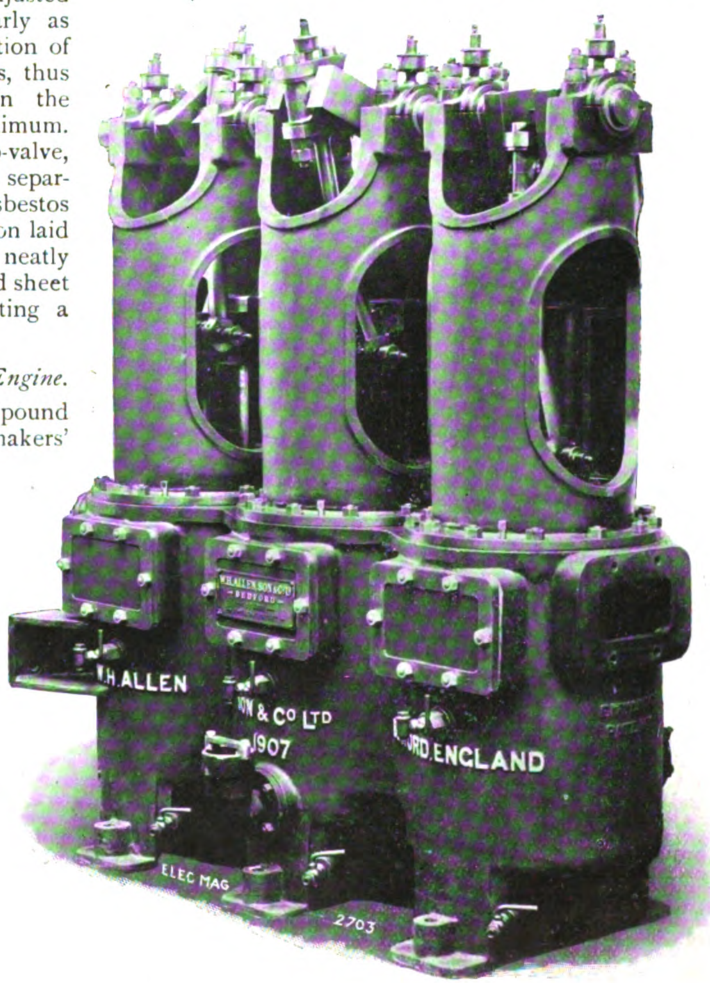


Fig. 3. Allen-Edwards Three-Throw Air Pump.

"Allen-Edwards" three-throw air pumps. The larger has been constructed for a condenser of 10,000 sq. ft. and has three barrels exactly similar with a diameter of 18in. and a stroke of 14in., the crank-shaft to make 135r.p.m. This is arranged for driving by means of a motor developing 19b.h.p. and running at 575r.p.m. The air pumps deliver the condensed water into a small surge tank situated in the lower part of the air-pump casing. This water is withdrawn by means of a single-acting force pump having a plunger 7in. in diameter and a stroke of 10in., and capable of delivering against a head of 10ft. This pump is driven from an outside disc crank on the end of the air-pump crank-shaft. The crank-shaft and connecting rods of the air pumps are of the best open-hearth mild steel, the bearings being lined throughout with white metal with the exception of the crosshead bearings, which are of gun-metal. The lubrication is effected throughout by means of "Stauffer" spring grease cups. The crosshead guides are cylindrical and bored at one setting with the facing of the trunk to which they are fixed, thus ensuring a perfect alignment. The air-pump buckets are of cast iron, and are fitted with a solid gun-metal ring. The barrels are of solid gun-metal, as also are the valve plates, the valves being of the "Kinghorn" metallic type resting on accurately faced seatings. The force pump is also fitted with gun-metal plunger and liners, and the air-pump casing is fitted with the usual accessories, such as snifting valves, drain cocks, and relief valves.

The large tube-plate shown on this stand is one of those constructed for the condenser just referred to, there being no fewer than 3751 holes drilled, counter-sunk, and tapped in this plate. The diameter of the tube-plate is 7ft. 4in., and the thickness $1\frac{1}{2}$in. This will give some idea of the necessity which the makers have found for the development of drilling and tapping machinery in their works to enable them to produce this special class of workmanship at a moderate cost.

Messrs. Allen also exhibit a smaller three-throw air pump, having barrels 12in. in diameter with a stroke of 10in. This has exactly the same general features as that just described.

Turbine Pumps.

An interesting exhibit on this stand is one of Messrs. Allen's four-stage turbine pumps, which is direct-coupled to a continuous-current motor, and is shown running, drawing water from a cast-iron tank below the pump and motor and delivering through a throttle and nozzle, a pressure gauge being situated behind the throttle, showing the head upon the pump. This pump has branches 4in. in diameter and is capable of delivering 100 to 120 gallons of water per minute against a head of 200ft. to 250ft. when running at 1700r.p.m. The pump casing is of cast iron and the spindle of high-grade nickel steel completely encased with gun-metal sleeves. The four discs are of bronze, as are also the fixed guide-blades in the casing of the pump. The spindle is carried in bearings of the self-oiling type, arranged externally to the pump casing, and at one end is provided with a small collar thrust bearing, which is automatically lubricated and cooled, and which takes up any slight unbalanced end-thrust which may occur during running. The glands through which the spindle enters the casing are of special design, owing to the high speed of rotation, that at the suction end being water-sealed, the water being drawn from the discharge side of the pump. The drive is transmitted to the pump spindle through a flexible coupling, and great care has been taken in the design of these pumps that the critical speeds of the pump spindle shall lie sufficiently above the normal speed of working to give freedom from vibration in running, and the employment of a flexible coupling ensures that these critical speeds will not be modified by the connection with the electric motor. The smooth working, the small space required, and the fewness of the working parts of this class of machinery ought at once to commend it to all who are seeking suitable pumping machinery, especially for high lifts. The electric motor is of Messrs. Allen's high-speed continuous-current type, and is specially designed for this class of work. Great care has been taken in the mechanical design to ensure durability and good running over long periods without attention. The motor is fitted with a pair of commutating poles situated in two of the inter-polar spaces, thus giving excellent commutation under all conditions of load with the brushes fixed in the neutral position.

The combination is set into operation by means of one of Messrs. Allen's drum

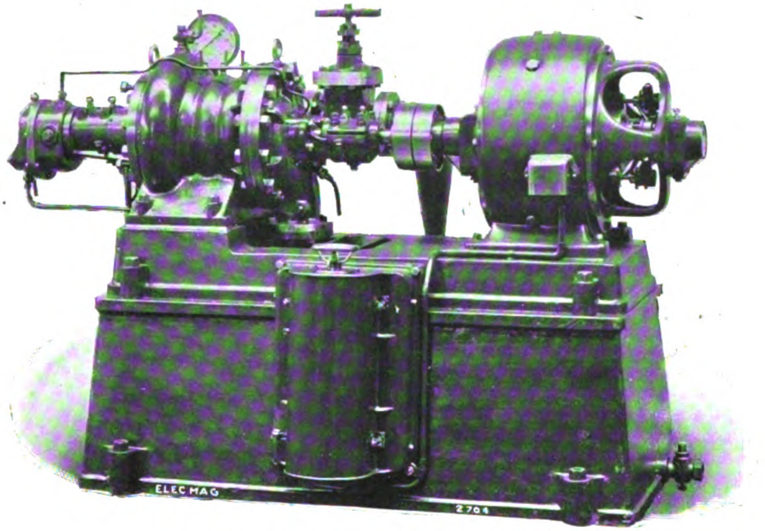


FIG. 4. ALLEN TURBO-ELECTRIC PUMPING SET.

tramway-type controllers. The arrangements are such that the motor is accelerated to its normal speed in passing the first four steps, and any subsequent regulation of speed which may be required is obtained by inserting resistances into the shunt of the motor in the last five positions of the controller barrel. A feature of the controller is its compactness as well as the accessibility of its various parts, and the entire absence of the use of solder. The connections are so arranged that the circuit of the motor is broken on both poles in the controller, the main switch being fitted with easily renewable carbon tips.

A three-stage turbine pump is also shown, having a discharge branch 7in. in diameter. This pump is claimed to be of an exceedingly economical construction, and has internally the same general features of design as those just described in the case of the smaller pump.

Oil Engines.

Many visitors to the Exhibition will have heard that Messrs. Allen have taken up the manufacture of paraffin-oil engines, and that these engines have secured a strong position in the markets of late. These are represented by a small two-crank combined oil engine and dynamo, the engine having two cylinders 4in. in diameter, with a stroke of 5¼in. This engine is capable of giving 5b.h.p. when running at a speed of 800r.p.m., the output of the dynamo being 2.75 kw. at 100 volts. This engine has been designed to withstand rough usage, and is suitable for long continuous runs with a minimum amount of attention. It is totally enclosed, and splash lubrication is employed, the cam shaft, which is driven by spur wheels, and which also carries the governor, being arranged inside the crank-chamber. The trunk is a rigid box-form casting carrying the main bearings and the cam shaft bearings, the bottom of this casting forming a well for the lubricating oil. The vaporiser is heated for starting up with a small blow lamp, but when the engine commences to work this

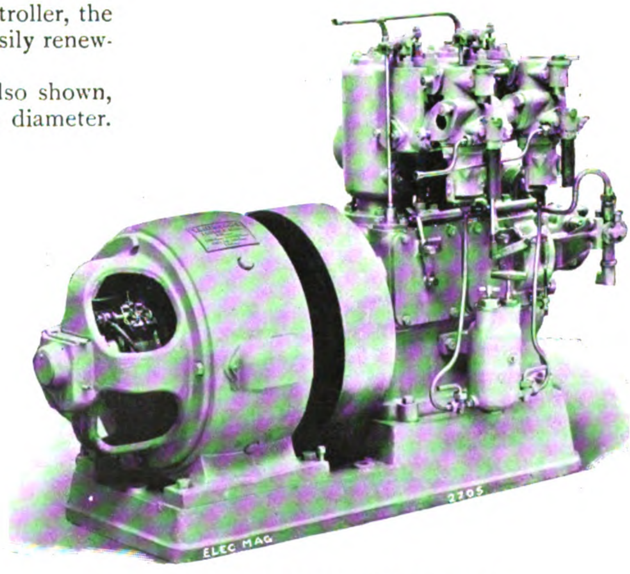


FIG. 5. ALLEN OIL-ELECTRIC GENERATING SET.

lamp is extinguished, the vaporiser being maintained at a suitable temperature by the heat of the exhaust; it is designed in such a manner as thoroughly to evaporate the paraffin without overheating the air which is required for completing the charge. Perfect combustion is obtained, and the vaporiser will remain clean and free from any deposit after months of continuous working. The governor, which is situated within the crank-chamber, controls a balanced throttle valve, placed close to the inlet valve. The ignition is effected by a low-tension magneto driven by spiral gearing from the crank-shaft. One hand lever operates the retarded ignition and exhaust relief cam for facilitating the starting up of the engine. Small brass plates are fixed indicating the starting and running positions of all levers, making it difficult for even an inexperienced hand to fail in starting the engine.

Mather & Platt, Ltd.

The stand occupied by this well-known firm is situated close by the main entrance to the British Section of the Machinery Hall, and the exhibit, which includes a variety of large plants, is proving one of the most attractive features of this section of the Exhibition.

Gas-electric Generator.

Prominent amongst the several heavy pieces of engineering work exhibited to advantage is the 800b.h.p. twin-cylinder two-cycle gas engine. This engine is rated for a normal speed of 107r.p.m., and to give its full output of 800b.h.p. continuously, with a gas supply of about 140 British thermal units per cubic foot; or in other words, with a fuel consumption of about ¾lb. of coal per horse-power hour.

This design of gas engine is the most similar to a steam engine of any made; it is claimed to equal the steam engine in reliability, even turning, and certainty of starting. There are no side shafts, cams, or gear wheels, and no exhaust valves. The engine is suitable for working with either town-lighting, producer, blast-furnace, coke-oven, or any other form of gas, and is in every way suited for the driving of electric generators, pumps, blowing engines, or for the main drive of works and factories.

A three-phase generator is mounted direct on the shaft between the two cylinders of the engine exhibited. It is rated for an output of 2200 volts, 170 amperes, at 25 cycles per second, which with a power factor of 0.8 is equivalent to 520kw.

Steam-turbine Pumping Set.

This set is designed to run at 3000r.p.m., and the turbine, of the Zoelly type, will develop 210b.h.p. when supplied with steam at a pressure of 160lb. per square inch, and condensing.

The pump has a capacity of 1200 gallons per minute against a total head of 400ft.

The turbine is of the multi-stage impulse type having wheels forged in one piece of the highest-grade steel and fitted with blades of nickel steel. The main bearings are fixed independently of the casing so that they are not subject to heating, there is no end thrust on the shaft, and the makers claim that they have upwards of 10,000h.p. in use in electricity works.

Electric Centrifugal Pumping Set.

Another noteworthy exhibit is the pair of patent high-lift turbine pumps direct-coupled to a direct-current steel-clad motor, placed between the two pumps. The motor runs at 1060r.p.m., and is capable of giving out 150b.h.p. The two pumps, which have each six successive chambers, through which the water passes, are connected in series, and are capable of delivering 400 gallons per minute against a total head of 720ft.; that is, each of the twelve chambers in series furnishes pressure sufficient to overcome 60ft. —that is, when the pump speed is 1060r.p.m. At 1450 revolutions the output would be 500 gallons per minute against 1300ft., and at 1850 revolutions 600 gallons per minute against 2000ft. head.

Amongst other plants and machines exhibited by Messrs. Mather & Platt are to be noted steam-driven boiler-feed pumps, cast-iron tanks, fire-pumps, Grinnell sprinklers, &c.

Applebys, Ltd.

Transporters.

This company are showing at their stand in the Machinery Hall working models of the well-known Temperley Patent Transporters. The models represent two of the many types in which these transporters are made, viz., the Temperley Travelling Bridge Transporter with automatic grab (Fig. 1),

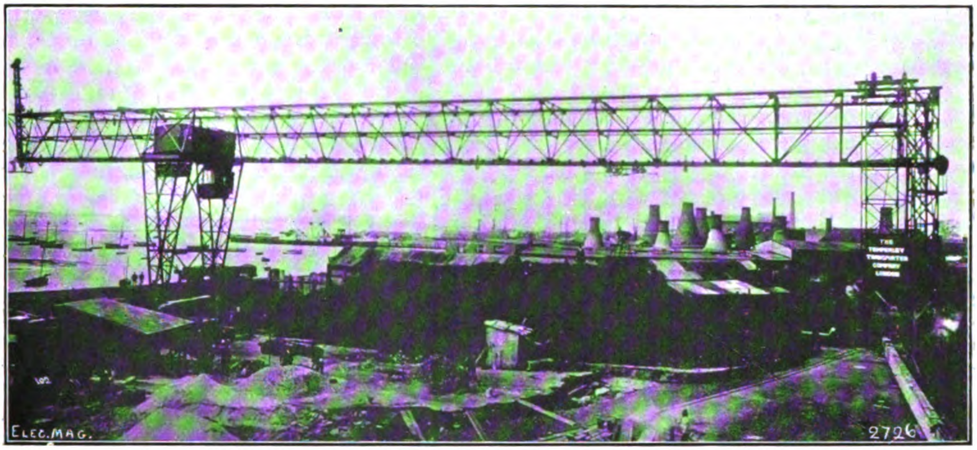


FIG. 1. TEMPERLEY TRAVELLING BRIDGE TRANSPORTER. APPLEBYS LTD.

and the Temperley Travelling Tower Transporter with automatic dumping skip (Fig. 2). Both models are shown working in coal, and the transporters are very largely used all over the world for dealing with this and a great variety of other materials in bulk. The transporters are designed in various forms, capable of handling from 50 to 200 tons of material per hour. Apart from an improved structural design, their principal feature is the special and simple form and the high efficiency of the hoisting and transporting machinery, by means of which the operations of hoisting or lowering and of transporting may be carried on separately or together without either operation influencing or inter-

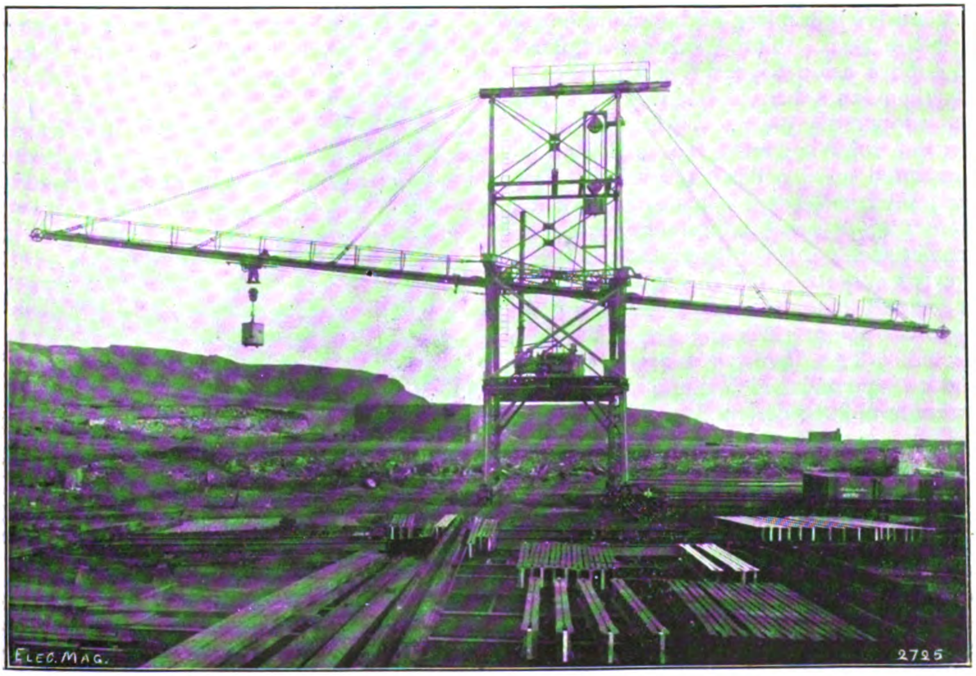


FIG. 2. TEMPERLEY TRAVELLING TOWER TRANSPORTER. APPLEBYS, LTD.

fering with the other. The load may thus be carried along the shortest trajectory from the point where it is picked up to that where it is delivered, thereby effecting a considerable saving of time. The same machinery also gives complete command over the closing and opening of the grab, these operations being effected either quickly or slowly in any desired position at the will of the operator. The grab may thus be lowered without loss of time close down to the stock heap, and the material deposited without breakage or dust. The operation of the plant is simple, and is easily controlled at a high rate of duty by one man.

The grabs are of the two-rope type, having large digging capacity in proportion to their weight, powerful closing action, and although made with plain cutting edges, they completely fill themselves even when working in the largest hard coal. They are so suspended that, although no guy ropes are used to steady them, they do not twist or get out of square. When the grab is being hoisted or transported only one-third of the total weight is taken by any one rope, so that the stresses on ropes, sheaves, and attachments are relatively small.

Provision is made for supporting the ropes on sheaves at intervals close under the track, thus entirely preventing undue sag when the ropes are slack. These sheaves automatically move aside to allow the traveller to pass them, and then close in again behind it to support the ropes. With this arrangement of rope supports the load may be transported at any desired level or along any desired trajectory. This is not possible where trapeze supports are employed, because in such cases the load must necessarily in every case be lifted the full height and transported along above the level of the supports before lowering can be effected. This involves a waste of time and power, which these transporters have been designed to obviate.

When extended over water the ends of the cantilevers are usually made to hinge up to allow vessels to come in and out of their berths. When the end is in the hinged-up position the transporter may nevertheless be worked for removing coal from the wharf or stock heap. The travelling bridge transporters are, when required, made so that either of the piers, or supports, may be moved along its track independently of the other, and the transporter placed at any angle up to about 10deg. on either side of the normal position.

The exhibit also includes a model of a crane and automatic grab for handling coal, coke, sand and gravel, iron ore, &c., together with a collection of very interesting photographs representing the large electric and steam cranes, and also the other machinery in which Messrs. Applebys, Ltd., specialize.

W. H. Bailey & Co., Ltd.

This Manchester firm exhibits quite a wide variety of specialities in the Machinery Hall, ranging from steam plant fittings and air compressors to motor-car accessories.

Air Compressors.

The first machine to be noted is the Köster patent air compressor, of which two or three types are shown. It is claimed for this machine that it gives the highest volumetric and mechanical efficiencies, and is suitable for all purposes where compressed air is required. It has a mechanically operated piston valve for admitting air to the cylinders, and only one outlet valve, the action of which is controlled by the piston valve, so that it is allowed to open wide and to seat itself noiselessly. Opening wide, it can be made small in diameter, leaving the whole of the cover of the cylinders and a

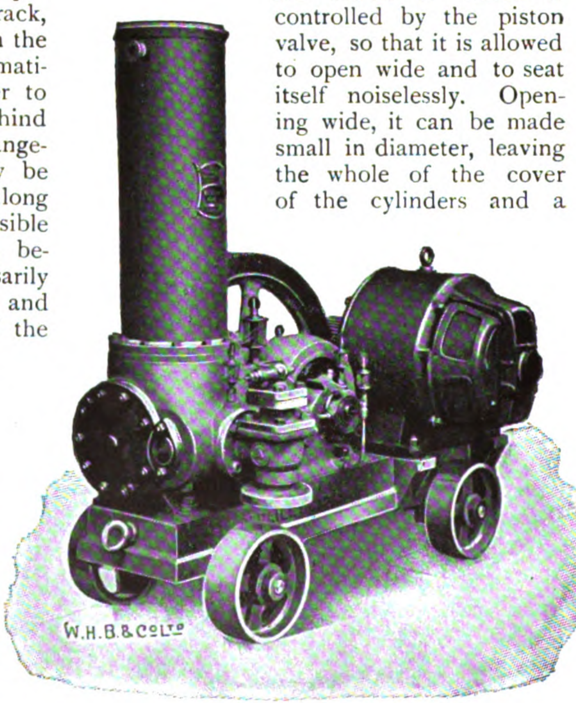


Fig. 1. Bailey Portable Electric Air Compressor.

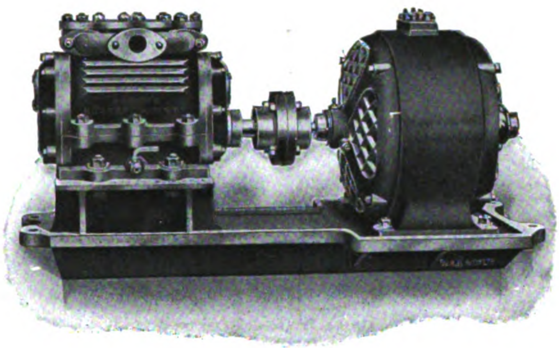


FIG. 2. ELECTRIC AIR-COMPRESSOR.

great part of the cylinder jacket available for cooling. The Köster patent valve gear enables the compressor to be run at high speeds; thus it is particularly suitable for being driven by the most economical type of electric motor or other prime mover.

One of the compressors shown is designed for running at a speed of 1000 r.p.m., and can be directly connected to an electric motor. It has a capacity of about 12 cubic feet of free air per minute, compressing up to 90lb. per square inch. This compressor could be used for a very wide variety of purposes, such as for the cleaning of dynamo and motor parts, supplying air for blowing whistles or syrens, operating compressed air brakes, &c.

Gauge-testing Apparatus.

The Bailey patent pressure and vacuum gauge tester, which forms a prominent feature on the stand, is suitable for testing pressure gauges by actual dead weight and vacuum gauges by comparing them with an open column mercurial vacuum gauge. The whole apparatus is assembled complete on a substantial cast-iron bed, and pressure and vacuum pumps are provided. This is a very compact and useful machine for use in works where many gauges require to be tested. Testers for dealing with cements and oils are also shown. It will be remembered that W. H. Bailey & Co. have been in the front for many years as makers of all classes of testing machines.

Steam Fittings.

There is also shown a large showcase containing samples of many of the engine and boiler fittings made by this firm, such as steam pressure gauges, vacuum gauges, valves, cocks, lubricators, water gauges, steam pressure and other recorders, &c. Particular reference should be made to the "Key-ring" renewable valve seat, which is fitted in stop-valves for high-pressure superheated steam. It allows for differences of expansion between the seat and the body, and can be easily removed and replaced. The principle of the "Key-ring" is the adoption of a flexible metallic connection between the seat and the body, similar in construction to the well-known Ramsbottom piston ring.

The seat of the ordinary type is screwed into a spring ring which is sprung into a groove in the valve body. The seat can be removed and replaced with ease, will expand freely in all directions, and remain tight under all pressures and temperatures.

The Foster reducing valve is a spring-controlled valve, which will open from any degree to full bore, according to the demand made on it. This is accomplished by means of its differential spring arrangement, which maintains a constant pressure on the governing diaphragm, irrespective of the degree of compression of the spring.

Motor-car Appliances.

W. H. Bailey & Co., Ltd., have recently been giving attention to the motor-car trade, and have introduced two very useful accessories, viz., the "Miloscope" and the patent "Open-door" tyre carrier.

The "Miloscope" is a speed indicator fashioned on the principle of the concave form assumed by the surface of liquid in a rapidly rotating vessel. It practically consists of three tubes and a revolving vessel. According as the vessel revolves—driven by friction from the front wheel of the car through a flexible shaft—the level of the liquid in the centre tube rises or falls, carrying with it a float which points to the speed figure on an attached scale. The simplicity of the arrangement is apparent, and it is claimed to have proved itself in every way a practical success.

The patent tyre-carrier consists of a metal ring hinged to a pillar. It is fixed to the footboard of the car, and can be opened or shut like an ordinary door or gate, thus giving easy access to the driver's seat, accumulator boxes, and petrol tank, besides facilitating the cleaning of the car. It is designed

fering with the other. The load may thus be carried along the shortest trajectory from the point where it is picked up to that where it is delivered, thereby effecting a considerable saving of time. The same machinery also gives complete command over the closing and opening of the grab, these operations being effected either quickly or slowly in any desired position at the will of the operator. The grab may thus be lowered without loss of time close down to the stock heap, and the material deposited without breakage or dust. The operation of the plant is simple, and is easily controlled at a high rate of duty by one man.

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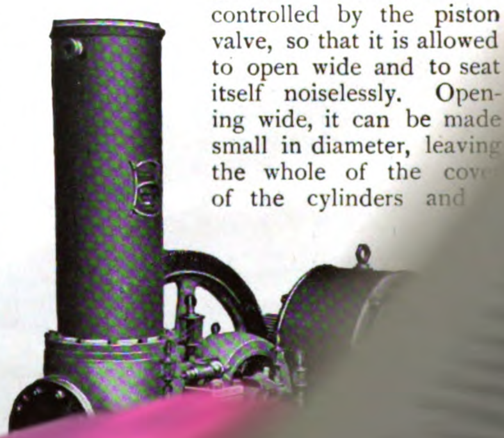

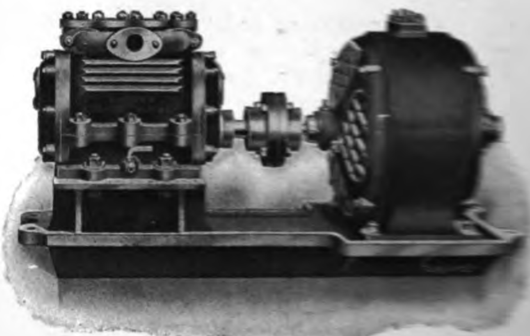

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[illegible] ectromotors, Ltd., have a show here of [illegible] of their various motors, while the Adams [illegible] anufacturing Company show switch-gear [illegible] longside. The last exhibit is that of the Stearn Electric Lamp Company, who are showing their new "Leuconium" metallic-filament lamp, the speciality of which is that each separate low-voltage element is contained in a separate small lamp, the whole group of as many as may be required being run in series in such a way that failure of any one filament does not necessitate the extinction of the whole lamp.

Such, in brief, is the "Collective Exhibit of the Electric Supply Companies," which has established itself as one of the most popular centres of attraction. Several of the more interesting parts of this exhibit are dealt with at greater length in the following pages, as are the exhibits of other electrical manufacturers who occupy separate stands or positions in the exhibition.

As will be gathered, the aim of the

to take any make of spare wheel or tyre, and can carry one or more spare covers by means of straps.

Electrical Machinery, Materials, and Appliances.

The Collective Exhibit of the Electric Supply Companies.

THE exhibit, broadly speaking, consists of three sections, the reception pavilion, the model flat, and the annexes, but before describing these in detail it may be well to generalize a little.

In the first place the authorities participating are the following companies:—All London companies, Harrow Electric Light and Power Company, North Metropolitan Electric Light and Power Company, South Metropolitan Light and Tramway Company, Oxford Electric Company, Bromley Electric Light and Power Company, and the District Councils of St. Marylebone, St. Pancras, Barking Town, and Leyton, acting through a committee of the Chief Officials of the London Electric Supply Companies, with Mr. F. J. Walker as Honorary Secretary.

The erection and furnishing of the pavilion and model flat were entrusted to Messrs. Waring & Gillow, and are carried out in that firm's well-known style, while the whole of the wiring and installation work was done by Messrs. W. Leonard & Co., Electrical Contractors, 4, Soho Street, Oxford Street, W.

The list of exhibitors with separate stands comprises:— Messrs. Dowsing, Waygood, Reyrolle, Westminster Engineering Company, Imperial Lighting Company, Duncan Watson, Electromotors, Adams, Hawkes, British Thomson-Houston, Stearn Electric Lamp Company, Ediswan, Berry & Skinner, Linolite Company, Huttons, Renolds, and Kinetic Swanton, while others have places in the pavilion and are mentioned in detail later.

Commencing with the pavilion, the entrance to which is flanked by two "Reason" lamp-posts, on each of which is a miniature "Reason" arc lamp, the announcement at the door shows it to be "The Reception Room and Information Bureau of the Supply Companies of London." Entering, the eye is caught by an effective miniature illuminative fountain, which cools and scents the air of the salon.

This fountain is shown by Messrs. Keith, Blackman, & Co., and forms, as it were, the centre-piece of the room.

The advertizing and "informing" literature of the various supply authorities is displayed on the tables and stands disposed about the rooms, as is also that of the manufacturers taking part in the exhibit.

On the left of the door as one enters is an effective show-case of the London Decorative Metalworks, Ltd., with switch-plates, &c., prepared by a special electric process, and which exhibit features of the highest artistic merit and finish. The window bay adjoining the showcase of the London Decorative Metalworks, Ltd., is devoted to the fittings, &c., of Messrs. Galsworthy, Ltd., of Newman Street, Oxford Street. The next panel on the left wall is monopolized by Messrs. Verity's, Ltd., with a show board of flush switch-plates and two panels containing wall brackets.

The centre panel is devoted to maps and photographs of the London districts and central stations, while alongside Bastian meters claim attention.

A Steinway "Welte," or automatic pianola piano, comes next, and has proved a great attraction to the public.

"Reason" Meters, Demand Indicators, and Testing Instruments make an effective display in the centre panel opposite the door, and close to them is the show-case of Messrs. Lundberg, with a complete range of their accessories.

The centre panel of the right-hand wall is taken up with a carefully-arranged collection of brackets and table lamps by the Birmingham Guild of Handicraft, of Newman Street, Oxford Street.

Messrs. Simplex, Ltd., have the adjoining panel, and show their conduit and brackets, &c., and in a wall case just to the right of the door on entering is an exhibit showing the various lamps made by the Sunbeam Lamp Company.

The centre stands contain an assortment of Messrs. Verity's "Typhoon" fans and afternoon tea kettles, and below them are arranged radiators and convectors of various types.

The general lighting of the pavilion consists of four Verity 5-light electroliers and an Ediswan arc lamp with inverted reflector.

There are two Ediswan alternating-current ceiling fans, and just overhead as one enters is one of Messrs. Bergtheil & Young's new punkahs, which "flicks" steadily throughout the day, and proves a great attraction to visitors, especially those from

India. Grouped round the pavilion are stalls of some of the manufacturers, that towards the entrance to the Machinery Hall being the exhibit of Messrs. Dowsing, who are chiefly showing the application of electricity to medical practice, and have a large display of apparatus for the local application of heat and electric light, together with X-ray apparatus, &c.

The stalls at the other end of the pavilion are those of Messrs. Ediswan, who make a selection from the large range of their manufactures ; next to them comes that of Messrs. Berry, Skinner & Co. with switch gear, &c., and a refrigerating plant ; while next to them, again, is the display of the Linolite Company.

Turning now to the model flat arranged and furnished by Messrs. Waring & Gillow:

This consists of a complete flat, of hall, dining and drawing rooms, bedroom, night nursery, and kitchen. The furnishing is an example of Messrs. Waring's "£200 complete" style, while the electrical apparatus on show in the various rooms is of various origins. The Prometheus apparatus, supplied by Messrs. Rashleigh Phipps, is used for all the very complete heating and cooking arrangements, the fans being Ediswan make, with the exception of the small punkah in the nursery, which is Messrs. Bergtheil & Young's.

The kitchen contains an example of everything electric for that department, a complete "batterie de cuisine" and oven (Prometheus), and a knife cleaner, boot cleaner, and plate polisher by Messrs. Electromotors.

In the bedroom is also shown an electrically-operated Singer's sewing machine with a Delhi motor.

The expense of lighting such a flat is shown to be the small sum of £6 per annum.

There is a further group of stalls round the flat, that on the right of the entrance being Messrs. Waygood's with a model push-button lift, next coming Messrs. Reyrolle's with switch and fuse gear, &c. Adjoining is a display of the various arc lamps manufactured by the Westminster Engineering Company, of Victoria Road, Willesden. The Imperial Lighting Company come next with a display of electrical signs, motor-driven and otherwise.

On the next stand Messrs. Duncan Watson are showing fittings, &c., and an electrically-operated carpet sweeper and lawn mower.

Immediately opposite is the stand of Messrs. Hatton, showing an electrically-driven printing machine, and next to them are Messrs. Renolds with wood-working machinery of various descriptions driven by electric motors.

The Kinetic Swanton Company are showing their electrical blowing apparatus for church organs, with a patent stopping and starting mechanism, which is operated from the key-board by push buttons.

One of Barlow's patent lift models is shown adjoining this.

Opposite again is the display of the British Thomson-Houston Company, who are showing electrical cooking apparatus, flat-irons, &c., and adjoining them Messrs. Hawkes, Ltd., of 79, Aldersgate Street, make an effective exhibit of some of their many types of convector hot-air stoves, together with an electrically-heated Turkish bath for home use.

At this same end of the stall is found what is practically a small sub-station, which feeds the whole of the exhibits under the care of the combined companies. The switch-board is fitted with Messrs. Berry, Skinner & Co.'s switch-gear, &c., controlling two motor-generators of the Electromotors, Ltd., which are converting the 500-volt supply which comes from the Hammersmith supply sub-station adjoining.

There are five voltages in use on various parts of the collective exhibit, and all the supply is controlled from this point.

Electromotors, Ltd., have a show here of some of their various motors, while the Adams Manufacturing Company show switch-gear alongside. The last exhibit is that of the Stearn Electric Lamp Company, who are showing their new "Leuconium" metallic-filament lamp, the speciality of which is that each separate low-voltage element is contained in a separate small lamp, the whole group of as many as may be required being run in series in such a way that failure of any one filament does not necessitate the extinction of the whole lamp.

Such, in brief, is the "Collective Exhibit of the Electric Supply Companies," which has established itself as one of the most popular centres of attraction. Several of the more interesting parts of this exhibit are dealt with at greater length in the following pages, as are the exhibits of other electrical manufacturers who occupy separate stands or positions in the exhibition.

As will be gathered, the aim of the

promoters of the Collective Exhibit has been to impress the general public and particularly the house-wife with the hundred-and-one beneficial uses to which electricity can be applied in the making of the home beautiful. This they have succeeded in.

Rashleigh, Phipps & Co.

Electric Cooking and Heating.

This firm is showing a complete electrical kitchen, designed to entirely do away with the use of coal fires or gas stoves, the whole of the usual operations connected with cooking, as also knife cleaning, plate cleaning, boot polishing and ironing, being done electrically.

The cooking table, Fig. 1, which replaces the usual kitchen range, consists of a number of circuits, each controlled by two switches, giving three degrees of heat, pilot lamps being arranged to show which circuits are in use, and special arrangements are made to do away with all loose flexible cords. Fuses for the various circuits, together with the main switch and cut-outs, are mounted in two recesses above the switchboard, and an ammeter showing the total amount of current in use at any time is provided. In addition to the above-mentioned circuits, which are intended for use with frying-pans, saucepans, kettles, &c., there is exhibited an electrical oven on an entirely new principle (the first of its kind ever constructed), in which, on account of the high temperature obtainable in the new form of electrical element used, roasting and baking are performed with very much less expenditure of current than has hitherto been required. The oven is shown on the right-hand side of Fig. 2. The various regulating switches and pilot lamps in this instance form a part of the oven, rendering it entirely self-contained and suitable for fixing in a kitchen quite apart from the other portion of the cooking table. On the top of the oven is fitted a cooking hot-plate, a grill, and a toaster, all fitted with the new high-temperature elements as used in the oven. It is of particular interest to note that this is the first occasion upon which an efficient and practical electrical toaster has been exhibited. A small boiler, fitted with a tap enabling a supply of hot water to be obtained at any moment, completes the outfit.

A canopy is fitted over the cooking table which, with the aid of a small Blackman fan, provides for the efficient ventilation of the kitchen and prevents any smell of cooking penetrating to other portions of the house. The space under the cooking table is conveniently arranged with a rack for holding saucepans, &c., when they are not in use.

The cooking utensils shown in the kitchen suitable for use with the above fitments comprise stewpans, saucepans, frying-pans, omelette-pans, kettles, porringers, potato steamers, coffee makers, hot plates, steam cookers, braising-pans, and fish-kettles. A spacious hot cupboard for warming plates and dishes and keeping food hot is also fitted, and electric irons of various shapes and sizes are shown in actual operation (Fig. 3). Should the necessary space be available it is intended also to show an electrical plate and dish washer.

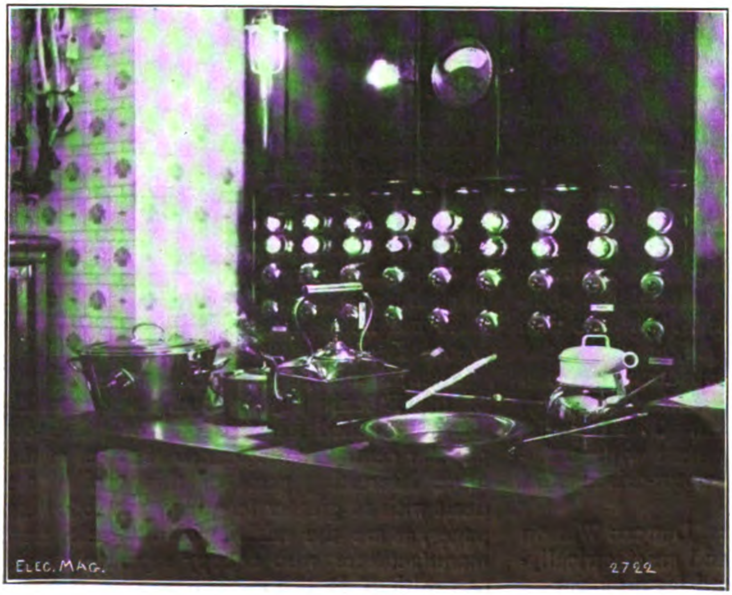


Fig. 1. The Electric Cooking Table.

In connection with

FIG. 2. GENERAL VIEW OF THE ELECTRIC KITCHEN.

Hall.—A small hat iron and a cigar-lighter.

Dining Room.—A hot plate and a kettle.

Drawing Room.—An afternoon tea-kettle and a foot-warmer.

Bedroom.—A bed-warmer, a bed foot-warmer, a curling-tongs heater, a particularly small and convenient form of hair-drier, a shaving-pot, kettle, hot-water jug, and a form of immersion heater used for heating water directly in the washhand basin or jug.

Nursery.—A milk-bottle steriliser, a flat-iron and a kettle.

Electric radiators of various designs for warming rooms are also shown, besides electric glue-pots and medical sterilisers.

the demonstrations of electrical cooking which are being given daily and frequently by Mrs. Deane throughout the run of the exhibition, the chief points which impress the onlooker are the ease of operation, absolute cleanliness, perfect control of heat (giving certainty of results), the entire absence of any noxious fumes (which are found so great a drawback to the use of gas-stoves for cooking), and the complete freedom from the unhealthy and unpleasant heat attending cooking by means of a coal range.

In addition to the above apparatus in the kitchen, various other domestic utensils of a similar character are shown in the various rooms of the model home as follows:—

It should be noted that the kitchen arrangements, having been installed with a special view to giving a thoroughly complete demonstration of electrical cookery in all its branches, are far more extensive and elaborate than would be in any way necessary for a house of the size shown, the accommodation provided being ample for cooking for thirty persons. It may be taken therefore that the installation shown represents a complete and up-to-date hotel equipment.

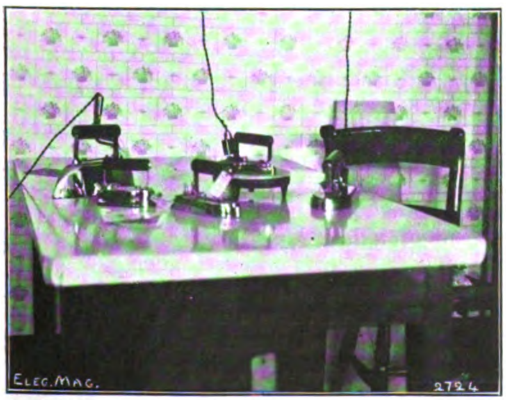


FIG. 3. EXHIBIT OF ELECTRIC IRONING.

Sherard Cowper-Coles & Co., Ltd.

Probably no one has done more towards applying the sciences of electro-chemistry and metallurgy to commercial and practical purposes than Mr. Cowper-Coles. The enormous amount of work which he has done in this direction is indicated to some extent in the variety of this company's exhibits, which include metal wall-paper, parabolic reflectors, aluminium welding, Sherardizing (a process of galvanizing), inlaying, or damascening of metals for art work, copper-depositing processes, &c., &c. The first two, as being based upon later discoveries and possessing more general interest, merit particular notice.

Metal Wall-Paper.

The discovery of a process whereby crude copper can be directly utilised to form continuous thin sheets, suitable in every way for the covering of internal walls, and at a low cost, introduces enormous possibilities. The metal wall-papers are perfectly pure and clean, and being of metal are naturally non-absorbent; cannot retain dirt or dust, and do not harbour or breed microbes; and are rapidly and effectually cleansed without the slightest risk of damage. They possess the additional important advantage that they are damp-proof and vermin-proof. Dampness cannot penetrate the metal wall-covering, and it not only retains its qualities under the most trying conditions but actually excludes moisture.

The most artistic effects are to be obtained in the metal wall-papers. A bewildering variety of choice colourings and elegant patterns, ranging from rich old oak pannelling to the most charmingly delicate French designs, are to be had. In fact, the choice is only limited by the possibilities of the artist.

So easily and economically are the patterns produced that for a nominal increase in the cost, anyone can have his own ideas executed even for small quantities, and the design reserved to himself.

Whilst wall-papers soon lose their freshness, and are besides seriously affected by sun and fog, their renewal is attended by serious inconvenience and expense. The metal wall-coverings withstand years of hard wear and exposure to the most trying climatic conditions, neither heat nor damp having the slightest effect upon them. The metal wall-coverings are eminently suitable for hotels, steamships, railway carriages, and public buildings, as well as private residences. They are naturally the ideal wall-coverings for tropical and other countries where heat, humidity, and the ravages of insects, and of white ants in particular, make ordinary papers and other substances impossible.

Whilst possessing insuperable advantages over every other wall-covering now in use, the metal wall-papers can be produced in the richest and most attractive designs at a price considerably lower than many of the materials now used.

From a sanitary point of view as well as from the equally important standpoint of beauty and economy, the metal wall-coverings commend themselves in every way to universal use.

New Metallic Mirror for Searchlights.

Ever since the introduction of searchlights for battleships, attempts have been made from time to time to substitute metallic mirrors in place of glass ones, which are unsatisfactory, due to the fact of their being so readily broken by concussion when firing the guns, and that the silvering at the back of the mirrors is very liable to blister and leave the surface of the glass.

The difficulty of making true parabolic mirrors has been overcome by the Cowper-Coles electrolytic process, which briefly consists of depositing by chemical means on the convex side of a glass former or mould a thin silver film, and then spinning the former in an electrolytic cell charged with copper anodes and a copper electrolyte so as to deposit the copper on the silver surface, the process being continued until the silver film has received a sufficient thickness of copper to give the desired rigidity to the parabolic mirror. The glass mould and the electro-deposit are then removed from the depositing cell and placed in a vessel containing cold water, the temperature of which is gradually raised until the expansion of the copper is sufficient to cause the metallic mirror to leave the glass former. The silver-faced mirror thus produced has as highly polished a surface as glass and is finally subjected to an after-treatment to prevent the silver from tarnishing, and is then mounted in a metallic ring (which fits in the projector case) provided with knife edges which firmly grip the mirror without distorting it. A large number of mirrors made by this process have been supplied to the War Office, some of which were sent out to the South African War. Mr. Cowper-Coles is now introducing a new metallic mirror which is only partially made by electro-deposition. The mirror has a surface composed of alternate bands or rings of gold and white reflecting surfaces, which it is claimed give a more penetrating beam of light both at night and in foggy weather. Objects on which such a beam of light is thrown stand out in greater relief than in a light thrown from a silver white-metal mirror, and the intensity of the light is so great that it is impossible to aim accurately at the projector. Another great advantage of the new mirrors is that they

are not fractured by concussion, and even when penetrated by bullets the area of distortion is very small.

The Westminster Engineering Company, Ltd.

Arc Lamps.

This company exhibits specimens of their enclosed type arc lamps consisting of the No. 108 brake feed type as used on the Central London Railway, Great Western Railway, Metropolitan Railway, at Baker Street and South Kensington, also by the General Post Office, &c. Another type shown is the small No. 115 type lamp taking a current of 3½amp., and which is particularly suitable for lighting small shops, corridors, waiting rooms, &c. One of this type, fitted with a silk shade, hangs in the middle of the stall for the general lighting of the exhibit, and is very effective.

The exhibit also comprises a number of "Westminster" photographic arc lamps, the speciality being a large No. 114 type lamp burning singly on a 500-volt continuous-current circuit. The arc is about 6in. long and the actinic power of the light is very great. Two similar lamps were used by the *Daily Mail* people on the occasion of the visit of the French President and King Edward to the Exhibition.

One of the photographic lamps is mounted on a tripod stand so that it can be moved about the studio to suit the requirements of the photographer.

A half-size model of a very handy printing frame with arc lamp and light shade on the top is shown. A lamp and frame such as this enables the photographer to do the whole of his printing quite irrespective of the state of the weather, in fact it is often found that photographers who get used to printing by artificial light are inclined to give up daylight altogether, the exposures being so much more easily managed by artificial light.

Limit Switches.

The Westminster Engineering Company also show samples of their new pattern limit switch. The switch is intended for use in those places where, for one reason or another, it can take the place of a meter; for instance, in large blocks of flats or offices it is found convenient by the electric supply authorities to put one large meter at the point of entrance of the supply, and provide a limit switch for each tenant of a flat or offices; the tenant is then charged so much per annum for current, his maximum not to exceed a specified amount; if this maximum is by accident exceeded the limit switch operates by opening and closing the circuit, so causing the lamps to blink violently until the current is reduced to the normal value. A noteworthy point about this particular limit switch is that the switch is shunted by a resistance, so that the circuit when broken through the switch is diverted through the resistance: the lamps are thus not wholly extinguished, but dimmed. The makers claim that this is the only limit switch of any use where metallic filament lamps are used, as, owing to the large starting current of this type of lamp, if the circuit is broken and the lamps extinguished the switch will continue to work until nearly all the lamps are switched off.

A number of interesting photographs are shown at this stand illustrating work done by the "Westminster" photographic lamps and also illustrating other of the manufactures of the Company, which include dynamos, motors, electric welding machinery, electric ventilating fans, switchboards, &c.

The Kinetic-Swanton Company, Ltd.

Electric Organ Blowing.

The Kinetic-Swanton Company, Ltd., devote themselves exclusively to the manufacture of machinery for blowing organs. It is claimed that they are the largest firm of this kind in the world and they have provided installations for St. Paul's Cathedral and twenty-one other cathedrals and for about 1200 churches and institutions. The exhibit consists of a Kinetic Blower direct-coupled to a 2b.h.p. Bull motor capable of blowing an organ of about 30 stops. The blower consists of several centrifugal fans of special construction, mounted on a common shaft, and operated in series or compounded so that the pressure generated by the first fan is intensified by the second and so on. The objects gained are efficiency and silence by reason of the slow speed—960r.p.m. The motor once started runs at constant speed and the consumption of current varies according to the wind used. The control is effected by a valve placed in the wind trunk connecting the blower to the organ, this valve being operated by the rising and

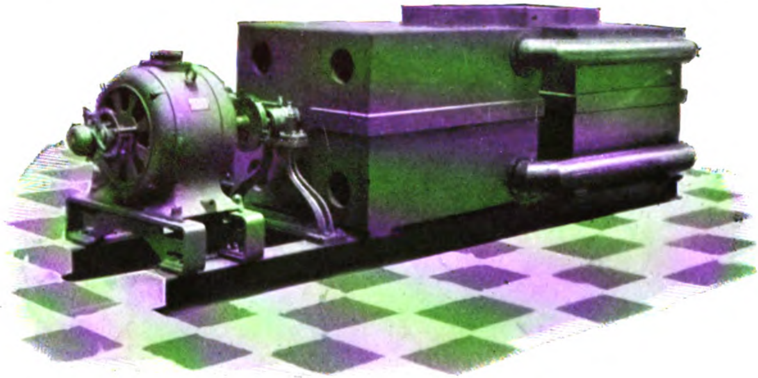


Fig. 1. Kinetic Swanton Electric Organ Bellows.

falling of the bellows itself. The average consumption of current for a blower of this size is about 1 b.t.u. per hour, and, contrasted with the hitherto universally employed method of controlling the motor by means of a rheostat, the saving is very great, working out in practice to about 70 per cent. The Kinetic blower can be operated by either D.C. or A.C. with entire satisfaction. In connection with this exhibit particular attention is directed to the patent Kinetic starter. This will start an A.C. or D.C. motor from any distance by a 6-volt current, and consists of a rheostat operated by a small power bellows connected to the blower. When the current is switched on—in case of D.C. as shown—the motor commences to revolve slowly. In doing so it generates a light wind pressure in the blower, which gently inflates the power bellows, and this in its turn raises the rheostat arm another step, thereby cutting out resistance, and so on until the rheostat arm is elevated to its limit, and all resistances are cut out. To stop the 6-volt current is switched off and a small armature valve opens and allows the imprisoned air in the bellows to escape, so that it collapses and brings down the rheostat arm with it. It will be seen that the arrangement is very simple and not likely to get out of order. It is stated to have been in operation for about five years without any complaint whatever.

The Aeromotor.

By this name is known the special type of centrifugal fan which has been designed for silent running. This is the first time this device has been exhibited, although it has been on the market for about eighteen months. It consists essentially of a very simple addition of a shroud or screen to the standard fan placed circumferentially round it, so that the air impulses created by vanes,

Fig. 2. Automatic Electric Bellows Controller.

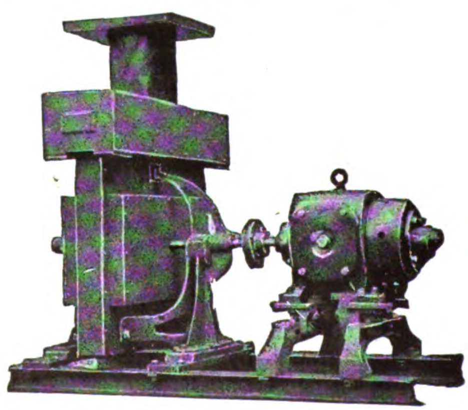


Fig. 3. Kinetic Swanton Aeromotor.

instead of striking the casing, are deflected at right angles.

Special attention is directed to the method of insulating the motors and blowers from the floor. The apparatus is placed on felt, and is not bolted down.

R. Waygood & Co., Ltd.

Automatic Electric Lift.

Messrs. Waygood exhibit a model to scale of one of their full automatic electric passenger lifts, so arranged that it dispenses with the constant services of an attendant. On each of the landings is fixed a call-button, and inside the cage is fixed a row of push-buttons corresponding to the number of floors served. On pressing either of these buttons the lift travels to, and automatically stops at, the desired floor. On each gate there are fixed electrical and mechanical locks so arranged that no door can be opened except that door on the floor being served by the lift, and likewise it is essential that all the doors are closed before the lift can be started. In some cases the lifts are fitted with self-closing doors, so that should the party last using the lift neglect to close the door after him, it will automatically close of its own accord, and so allow the lift to be called to other floors as required.

Adams Manufacturing Co., Ltd.

Automatic Control of Motors.

On approaching the stand of the Adams Manufacturing Co., Ltd., the first object attracting the attention is a large iron tank with a glass panel in its front, which stands on four pillars high up and prominent. Through the glass panel the visitor can see

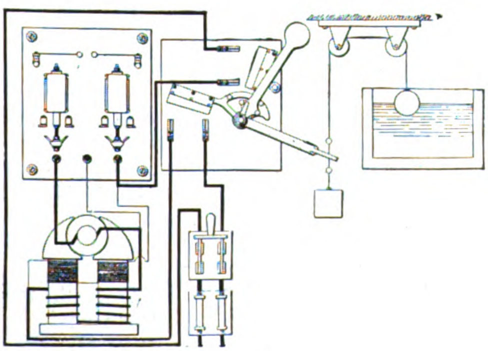


Fig. 1.

that the tank contains water, upon which a polished copper float is resting. The water from this tank is constantly flowing through a pipe to a second tank on a level with the floor, and whenever the upper tank is nearly empty a float switch (to which the polished copper float in the tank is attached) automatically brings into play one of the Adams "Igranic" self-acting motor starting rheostats, with the result that a Gwynn centrifugal pump on the adjoining stand is started, and the water is pumped back quickly from the lower tank to the upper. When the upper tank is full again, the float operates the float switch in the reverse direction, with the result that the motor and pump are stopped automatically and the water is left to flow slowly back again into the lower tank until the upper tank is again nearly empty.

This apparatus is exceedingly simple in construction, apparently requiring no attention, and it never fails to perform its allotted duty, day or night. It consists only of an automatic starting rheostat, a double-pole float switch, and the necessary float gear, *i.e.*, a copper float, pulleys, rope and cast-iron weight. The rope to which the float is attached passes over two pulleys, through an eye in the double-pole float-switch lever, and is then attached to the cast-iron weight (see Fig. 1).

It is a capital illustration of how country houses or buildings similarly situated may easily maintain a constant and reliable water supply, and the Adams Manufacturing Co., Ltd., advise that thousands of examples of self-acting apparatus of this character have been supplied by them and have been in use all over the country for years. Not only so, but at the present moment several people who object to the London Water Board's charges are taking steps to make themselves independent of the Board's supply by sinking wells and installing pumps controlled by the Adams "Igranic" automatic apparatus. Distance is no obstacle. At the exhibition the tank is on one side of the stand, the automatic starting apparatus on the other, while the pump and motor are on the next stand, and these distances might be increased to miles without affecting the operation of the apparatus.

A larger specimen of Adams "Igranic" self-acting control for a pump-motor is shown in connection with a Pearn three-throw pump, but for want of space this

FIG. 2

pump is not actually handling water, although it is started and stopped automatically so as to show the operation of the apparatus.

Other apparatus shown in operation includes a lift controller, which consists of an "Igranic," rope operated, reversing switch and an "Igranic" self-acting, motor starting rheostat (see Figs. 2 and 3). This is exceedingly small and, compact, and, consequently, is specially suitable for use in connection with dinner lifts. It is shown connected up and drives a motor fitted with reduction gear on the adjoining stand, and altogether illustrates in a graphic manner

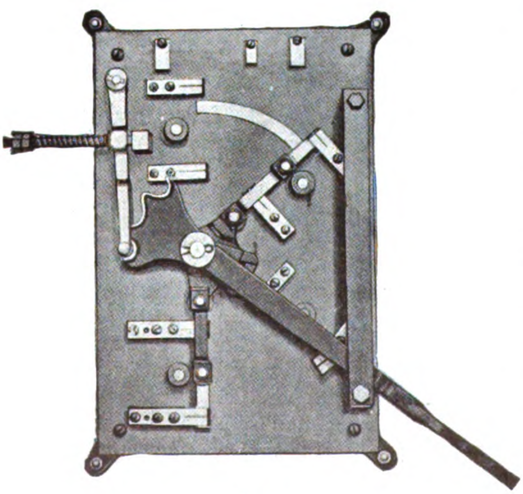


FIG. 3

how a service lift may be very simply and suitably equipped with electric drive.

With the increased use of electric motors for driving pumps, air compressors, hydraulic accumulators, lifts, &c., many devices have been developed for starting and stopping the motor automatically in a manner similar to those described above. It is a claim of the Adams Manufacturing Co. that they originated the manufacture of self-starting apparatus. Their "Igranic" types of automatic starters are familiar to every electrical engineer and power consumer in this country. Such apparatus reduces the wages bill considerably, by diminishing the number of attendants required, and by eliminating human mistakes and carelessness it ensures the starting and stopping of the motor at the required moment.

A 20h.p. self-acting motor starting rheostat is shown in operation actuated by two small push buttons, one for starting and one for stopping, and convincingly demonstrates how very easily the largest motors may be started and stopped from remote positions. This method of controlling motors is being very largely adopted in connection with printing presses, the Adams Manufacturing Co., Ltd., having within a very few months equipped several large printing works throughout with apparatus of this character. The advantages are obvious, either for printing works or for any kind of manufactory where the machines have to be frequently started and stopped by operators who have no knowledge of mechanics or of electricity, and who, furthermore, being on piece work, are far more concerned with getting the greatest possible amount of work out of their machine than with the careful starting and stopping of them. These self-acting motor starting rheostats remove all responsibility from the operator, and thereby eliminate a very frequent source of accident and damage to the machinery.

The largest example of this kind of apparatus which is shown in operation at the Adams exhibit is a 150h.p. 500-volt self-acting starter. The difficulty of starting up large motors is well known, owing to the excessive sparking that occurs on sliding contacts when heavy currents are handled. For this large power the Adams Manufacturing Company do not use the sliding type of contact at all, but, instead, the motor circuit is opened and closed by a solenoid switch, which is fitted with carbon

break contacts and a powerful magnetic blow-out; the various steps of starting resistance are cut out in succession by a number of similar solenoid switches, all of which close in their turn, and at the proper interval, with a snap movement, and make circuit by pressing a laminated copper brush against hard rolled metal surfaces (see Fig. 4). With this form of contact maker no partial contact is possible. There must always be either full contact or none, and this enables very heavy currents to be frequently made and broken without any damage to the switch. Such arcing as may occur must take place on the carbon contacts, which, of course, are very easily and cheaply renewable, and these again are protected by the magnetic blow-out. This type of starter may be made fully automatic when used with pumps, air compressors, or hydraulic accumulators, by introducing a float switch or pressure regulator.

An interesting piece of apparatus is the Adams "Igranic" printing press controller, which is designed for controlling large electrically driven rotary printing presses of the type used for printing the large London daily newspapers. This is capable of regulating the speed of the press through a very wide range, the ratio in some cases being 40 or 50 to 1. All the speeds are obtained by the use of only one handle, and only one motor, and, moreover, each step represents a definite and positive speed, so that if the controller handle is set on a step which should give a certain number of r.p.m., that speed will be positively maintained despite any variations that may occur in the load. Rotary printing presses call for a wide range of speed control. First, a very slow speed and high starting torque are required for setting up the plates on the rolls preparatory to printing. The plates being put in by hand, it is essential, both for the safety of the operator and to avoid damaging the paper by violent acceleration, that the press should start slowly, and that unexpected and unintended acceleration should be impossible. It should also be easy to stop the press immediately when necessary. After the plates have been set on the rolls and the paper threaded in, the press can be run at its normal printing speed. Provision must also be made for obtaining a high speed which would be necessary for a late edition of a newspaper or similar work.

In the "Igranic" system the slow initial speed of the press is obtained by means of a variable resistance, which is in parallel with the armature and in series, with a resistance which is also in series with the armature. The speed between the preparatory operations and slow printing speeds is produced by a resistance in series with the armature, while the high speeds are attained by cutting out the series windings of the motor and inserting a resistance in the shunt field. The entire range of speed control is effected by means of one controller lever (Fig. 5).

For starting, stopping, or "inching" the motor at a distance from the regulator, small

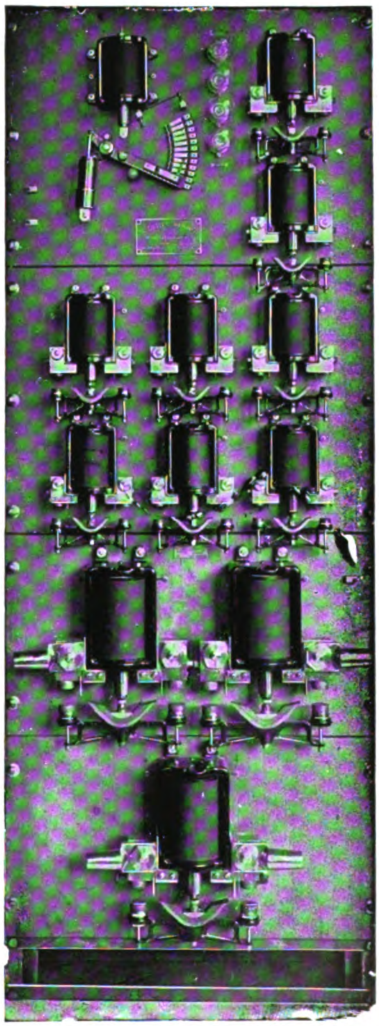


FIG. 4.

auxiliary switches are provided which avoid the frequent use of the controller lever. A solenoid-controlled switch fitted with powerful blow-out magnets and carbon breaks is used for opening the motor circuit, thus preventing injurious sparking at the controller brushes. Quite a number of these controllers have been installed in several of the large printing offices in this country, and they bid fair to supplant some of the older and more expensive printing press controllers now in use.

There are two examples of another type of controller which is suitable for motors driving reversible or non-reversible printing presses, machine tools, &c. This controller is considerably smaller in size than the type above described, and embodies a number of novel features. The speed regulation is effected by means of resistance in both the armature and the shunt field circuits. The field resistance is mounted on the back of the controller front, while the armature resistance is for convenience assembled in a separate box and the leads brought to the controller front. The controller provides a large range of speed. In sizes from $\frac{1}{2}$h.p. to $5\frac{1}{2}$h.p. there are eleven possible speeds, seven on the armature and four on the field. In the 10h.p. and 15h.p. sizes there are eleven speeds possible on the armature and four on the field, thus making a total of fifteen speeds. A no-volt or an overload release (or both) may be provided, and in addition an inductive dynamic brake. This brake, which is very effective and simple, is capable of stopping the motor almost immediately; it consists of an inductive resistance, which is thrown across the armature terminals whenever the motor is disconnected from the lines, no matter whether this is due to a failure of the supply, an overload, or an intentional movement of the controller lever. This inductive resistance consists of a coil, the considerable self-induction of which prevents the flow of a large amount of current when it is first thrown across the armature terminals; it exerts a powerful braking effect on the motor without causing any appreciable sparking at the commutator. The motor circuit is not opened on the controller steps, but on an auxiliary contact and in a strong magnetic field for disrupting the arc. Small switches for starting, stopping or "inching" the motor may be fixed at a distance from the regulator, for the convenience of the operator. Space does not allow of a detailed description of this exceedingly interesting apparatus, the use of which goes far to demonstrate the superiority of the electromotor over any other system of driving for use in printing offices and machine shops.

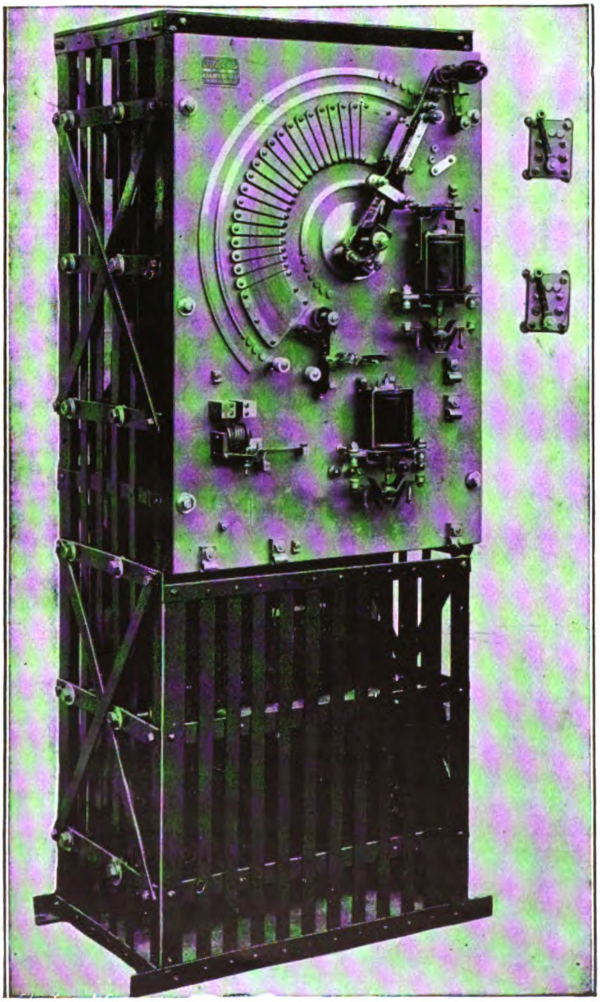


FIG. 5.

Another interesting item of the exhibit is a 30h.p. 220-volt reversible crane controller of the face-plate type. This has a vertical handle which is moved to the right for one direction of rotation and to the left for the opposite direction of rotation of the motor. All the contacts are easily renewable and protected by a magnetic blow-out, while the fingers which make contact with them are of a particularly novel and ingenious kind, securing good contact even on an uneven surface, and rendering renewals or adjustments exceedingly easy.

In addition to the interesting apparatus mentioned there is also a good representative show of the Adams Co.'s well-known standard "Igranic" specialities, including their ironclad field regulators; drum or tramway type controllers; motor starters, with no-volt and overload releases; fan regulators; a 90h.p. three-phase starter fitted with auxiliary contacts for preventing sparking at the main segments; an "Igranic" multiple switch rheostat for starting up motors up to 3000h.p. and many other types.

Undoubtedly it is largely due to the efficient methods of starting and speed control such as are exhibited on the Adams Co.'s stand, that the electric motor has reached its present success and is able to conclusively demonstrate its superiority over any other system of drive.

The Stearn Electric Lamp Company, Ltd.
Metallic Filament Lamps.

This is an interesting exhibit of English-made metallic filament lamps, known as the "Leuconium," and specially illustrating the use of these 1¼ watts per English candle lamps on a 220 volt circuit. The particular lamps shown are the "Nevaout" series lamps, these being all fitted with a special automatic fuse in the cap of the lamp and a substitutional carbon resistance in the bulb, so that, used in series, the failure of one lamp does not entail the extinguishing of the whole group as in ordinary series lighting, but, on the other hand, ensures the circuit being automatically maintained through the carbon resistance until a new lamp is put in place of the broken one.

The exhibit consists of a 5-light electrolier fitted with four lamps of 44 volts each, the fifth point being occupied by a double tubular fitting, each tube being 22 volts, the total making the 220 volts used on the circuit. There is also shown a 3-light bracket, each point being 74 volts, and in this case the two outer lamps are of bulb form, whilst the centre point is a 3-tube cluster. Below this are two 3-light brackets with all six points wired in series and consequently smaller c.p. at each point. There are two small standards illustrating the use of 55 volt lamps, four in series on 220 volts, one being fitted with ordinary bulb form lamps, the other with a special tubular form in clusters of three—a very ingenious device, and one considerably reducing the cost of renewals, as in the case of the failure of one filament it is only the single tube which has to be replaced instead of a whole lamp. This same system is admirably shown by two single-point drop lights used direct on the 220 volts, the one consisting of a 4-tube cluster fitting—each unit being 55 volts—and the other of a 5-tube cluster fitting, each unit being 44 volts. These demonstrate the system for single points, and it is evident that not only is the loss by breakage of the filament reduced to the cost of one tube instead of a whole lamp containing probably 7 to 10 filaments, but, whereas with the single light ordinary bulb form, if a filament breaks, the room is plunged in darkness, by this arrangement of automatic fuse the light is merely reduced by one-fifth in the one case and one-fourth in the other.

The Stearn Electric Company make a great point of the utility of this device for street lighting, for which purpose, where it is desired to have a yet larger spread of light, they are prepared to supply a 10-tube fitting. To demonstrate this they have fitted up an ordinary street gas lantern adapted for use with electric light on this system, and the fact that the complete lamp will not go out in the case of breakage of a filament, combined with the reduced cost of renewal in having to replace only one tubular unit instead of a whole lamp, will strongly appeal to the numerous corporation and other engineers who are interested in street lighting by electricity in smaller units than the arc lamp.

Wm. Geipel & Co.
Liconite.

Amongst the earliest completed exhibits in the electrical section was that of Messrs. Wm. Geipel & Co., which is of considerable

Fig. 1. Messrs. Geipel & Co.'s Exhibit.

interest to all engineers and will well repay a careful inspection. The leading feature is a leadless cable insulated with the new dielectric material termed "Liconite," of which some particulars were given in The Electrical Magazine of last month. Liconite is claimed to be suitable for practically all insulating purposes where rubber, bitumen, or impregnated paper are now used, and to be superior to them in many important respects. The new material is a patented compound of bituminous character, the invention of Mr. E. S. Ali Cohen, of Singapore. In its unvulcanised state it has the appearance of bitumen of a good quality. It is unaffected by acids,

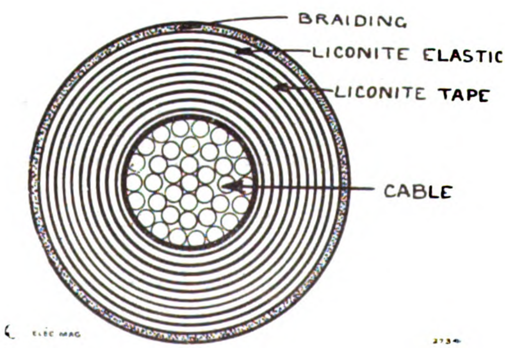


Fig. 2. Liconite Re-inforced Cable.

alkalies or oils, is non-hygroscopic, and does not flow or crack like bitumen. When prepared by vulcanising it is elastic and tough, possessing many of the advantageous qualities of rubber and gutta percha. Its insulating resistance is at the rate of about 300,000,000 megohms per cubic cm., whilst its capacity is about 4.2, which is approximately that of gutta percha.

The raw material is suitable for joint-box filling, and makes an excellent insulating tape. In addition to this, it can be applied to the manufacture of belting, insulating material, impregnating and water-proofing paper, canvas, &c.

A considerable range of cables for large and small currents is exhibited, and in particular one should notice the leadless paper cable which it is claimed is absolutely non-hygroscopic, and proof against dilute acids and alkalies such as are found underground. It has been the quest of electrical engineers for the last twenty years to provide means for the construction of a cable insulated with paper which can be safely used underground without the protection of a lead sheathing. The lead sheathing is not only expensive in itself, but it is a source of weakness to the cable. The maintenance of the insulating property of the paper depends upon the lead remaining intact; on the other hand the lead itself is subject to the deteriorating action of acids and other impurities found in the earth. Whenever this action eats through the lead, or should the lead be punctured by mechanical action, the insulating property of the paper is destroyed, and the cable fails.

The Liconite leadless paper cable, now exhibited for the first time, being without lead coating, is at once cheap to manufacture and easy to handle, whilst the paper is so thoroughly impregnated with Liconite that it is possible to lay this cable in water for an indefinite period without there being the slightest possibility of a breakdown.

The copper conductor of the length shown is .25 square inch and the overall diameter 1.38in. Notwithstanding that the thickness of the insulation is $\frac{3}{8}$in. only, this particular cable has withstood voltages up to 70,000 after long immersion in water and is rated for a working voltage of 30,000, at which it will transmit 10,000h.p.

The insulation consists of a series of Manila paper wrappings impregnated with Liconite; the protecting covering

of this particular length over the paper consists simply of two layers of Hessian tape. When necessary the cable may be braided as usual or armoured.

All the standard bending tests can be applied without producing cracking or weakening of the insulating coat. That this method of insulating is of the highest value is shown by the tests of 40,000 to 50,000 volts which are continually applied at the stand to a piece cut off this length of cable that remains permanently immersed in water.

A further advantageous feature of this cable is that the insulation being impregnated with an elastic solid, does not run or ooze; consequently the Liconite paper cable is very suitable for transmission down pit shafts and in other places where gravity is likely to cause the insulation of ordinary lead-protected paper cables to disappear. It is estimated that by adopting these leadless paper-covered cables a saving of from 20 to 30 per cent. can be made in the cost on account of the saving in lead alone, whilst being smaller and lighter the cable is easier handled, cheaper to freight, requires smaller ducts, and is generally less expensive to lay.

A further interesting sample is a cable insulated with re-inforced Liconite elastic. In this condition the insulation is of an elastic nature, very similar to vulcanized rubber, but, it is said, much more durable. It is intended to fill the position now occupied by ordinary bitumen cables.

The Liconite elastic is wrapped upon the cable in a series of thin layers, each layer being reinforced by a wrapping of Liconite fibrous tape. This cable is remarkable for its elasticity and resistance to mechanical injury; it can be bent almost double, and it is stated that the copper conductor will crack before the insulation. Owing to the elasticity of the insulation and the great strength afforded by this method of construction, decentralising of the core cannot occur and no flowing can take place under all ordinary variations in temperature. A length of this re-inforced elastic cable is shown having a copper area of .25 square inch and a total diameter of 1.6in. This is rated at 20,000 volts and has therefore a capacity for power transmission of 5000kw.

Another of the cables exhibited is stated to be the cheapest high-tension three-phase cable ever constructed. It is for a working voltage of 20,000 between each core. The conductor is of aluminium with a lead coating to reduce potential stress and is covered with vulcanized Liconite elastic without reinforcement; the overall diameter of the three conductors layed up is 3.5in.

From the foregoing, it would appear that the advantages claimed for Liconite-insulated cables are of high importance to those interested in the development of power distribution systems, and assuming these claims to be upon a sound basis, there is undoubtedly a wide field open to them.

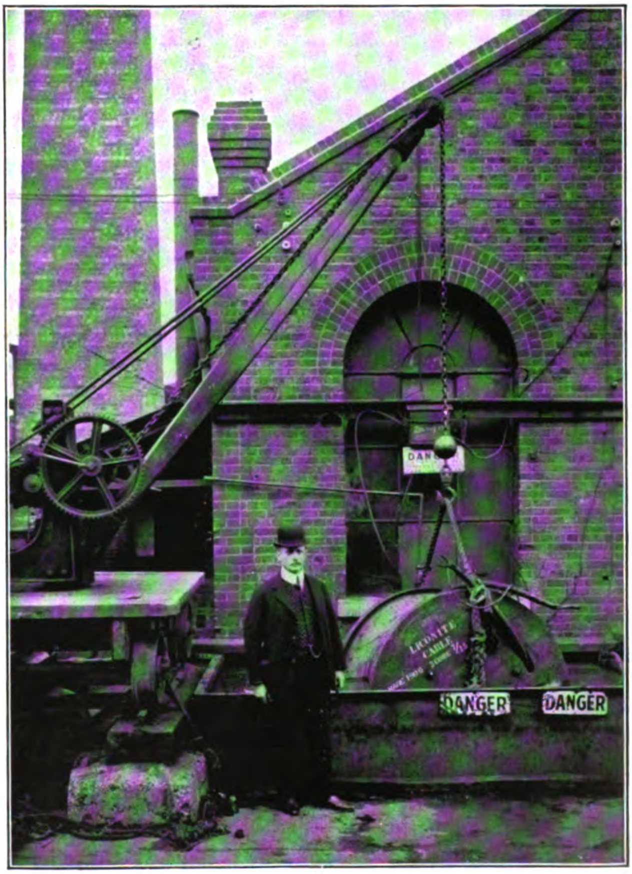
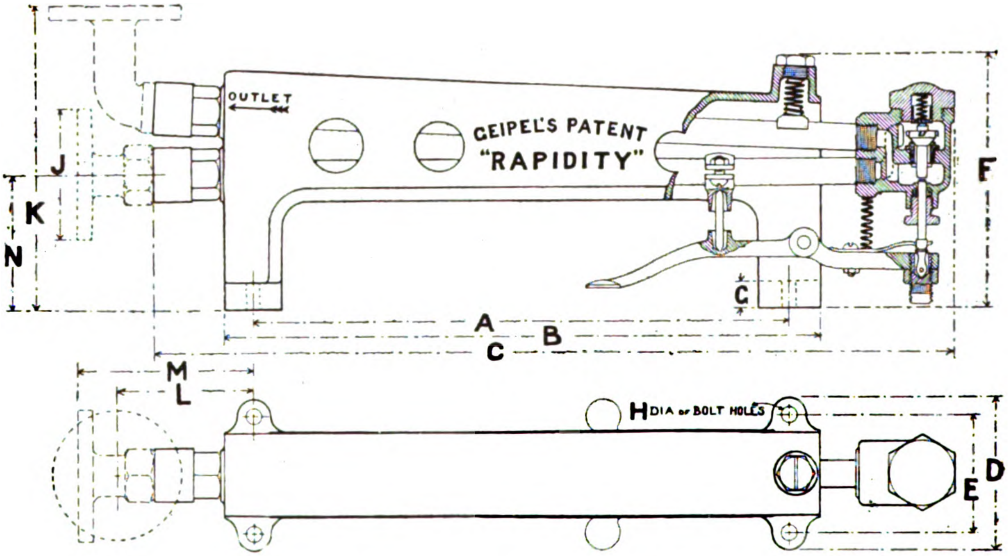


FIG. 3. DRUM OF LICONITE CABLE ON HIGH-VOLTAGE TEST.



SIZE OF TRAP	DIA OF INLET AND OUTLET	A	B	C	D	E	F	G	H	J	K	L	M	N
No. 1	3/4" *	16 1/8	17 7/8	24 1/16	4 9/16	3 1/2	7 9/16	1 1/16	7/16	4	9 5/16	4 1/16	5 7/16	4 3/16
No. 2	1" *	20 1/8	22 1/8	28 3/8	4 15/16	3 3/4	8 1/4	1 1/16	9/16	4 3/4	9 5/8	4 3/4	6 3/16	4 5/16
No. 3	1 1/2" *	21	23 1/2	30 3/8	6	4 5/8	9 3/4	3/4	9/16	5 1/4	11 13/16	5 3/16	7 5/16	4 7/16

* GAS

FIG. 4. THE GEIPEL RAPIDITY STEAM TRAP.

Geipel Steam Traps and Separators.

The latest improvements by Mr. Geipel have been introduced into the range of traps and separators exhibited. The new Geipel "Rapidity" trap works over larger ranges of pressures than the ordinary well-known Geipel trap, such for example as from 120lb. to 200lb., or in similar proportion for other pressures. The entire valve system has been re-arranged in such manner that a considerably larger area is available for the discharge of water and the valve rotates and is therefore self-grinding. An important point is the accessibility of the valve, which can be removed by merely unscrewing a readily removed cap; the valve, being quite free and disconnected, can then be taken out by the fingers.

A new model of the Admiralty pattern trap working from atmosphere up to 300lb. pressure without readjustment will well repay inspection.

A section of this trap is shown in the accompanying illustration, and on the stand there is exhibited an actual model in section, which shows the movement of the valve as it actually operates under expansion and contraction. A hand lever is provided which gives the same movement to the brass tube as occurs when the latter is first expanded by the heat of the steam, and then contracted by the coolness of the water before discharge.

Owing to the peculiar arrangement of the expansion parts, these traps do not dribble as is generally the case with expansion traps. They appear to open and give a full bore discharge with a sudden shut off.

The valve, it will be seen, is held upon its seat by steam pressure. It is lifted from its seat by the contraction of the brass tube, so that the expansion members are only under strain at the moment when the valve is being lifted. Immediately the valve is slightly lifted, the pressure is released and the

FIG. 5. THE GEIPEL ADMIRALTY RAPIDITY STEAM TRAP.

water, so to speak, wedges the valve fully open.

These traps can be seen actually at work on the stands of Messrs. Babcock & Wilcox and Messrs. Parsons Marine Steam Turbine Company.

There is also exhibited a new model of the Admiralty "Rapidity" trap, which is self-adjusting and works without adjustment from atmosphere up to 400lb. pressure. The automatic adjustment is obtained by means of a hydraulic cylinder, as is shown in the accompanying illustration.

The piston is spring-controlled, and the piston rod is attached to a tapered key, so that as the pressure of the water behind the piston forces this key forward, it alters the adjustment just sufficiently to compensate for the alteration in the position of the expansion parts due to the higher temperature of the steam. This trap, whilst holding steam at 220deg. F., will discharge water at 420deg. F., an apparently anomalous proposition, which is solved by the action of the automatic adjustment by pressure combined with the operation of the valve by temperature. All these traps have the advantage of a hand blow-through, which it will be observed can either be used by hand or by foot, the latter being frequently very convenient.

The makers advertise that there are now over 100,000 Geipel traps in use all over the world, and that this trap obtained the gold medal and a special merit prize of 1000 francs at the recent Brussels Exposition.

The Sunbeam Lamp Company, Ltd.

Incandescent Electric Lamps.

The Sunbeam Lamp Company, Ltd., of Gateshead-on-Tyne, as one of the oldest electric incandescent lamp manufacturers in the Kingdom, being established since 1887, are showing specimens of their various specialities. Practically every description of lamp that is in use to-day both for decorative and commercial purposes is made by them. It is of interest to note in this connection that this firm have their own glass works for the manufacture of the bulbs for the lamps; their products are thus English throughout. Of course, the greatest interest is here with the new metallic filament lamps.

The "Sunbeam" metal lamps, which the company are about to place upon the market, are exhibited as for high and low volt circuits, the former being seen hanging from brackets in the reception-room of the Collective Electrical Exhibit. It is said that these are probab y the first metallic filament lamps for high volt circuits that have been made by a British firm and exhibited in this country. These lamps are burning on a 220 volt circuit at an efficiency of 1.35 watts per c.p., each lamp being of about 55 candle-power. The low volt lamps are running at an efficiency of about 1.2 watts per c.p. with a candle-power of 30.

The filaments are claimed to be strong and likely to bear fair usage in transit, which was borne out by the lamps shown in use

and which arrived safely at the Exhibition from the works at Gateshead-on-Tyne without any special precautions having been taken with their packing. The Sunbeam Company advertise the fact that they are at the present time erecting a special factory for the production of these new metallic-filament lamps, and that they will thus be able to meet the demands of the coming season.

Amongst the other exhibits of this company are included electrical accessories of many types, such as insulators, holders, switches, &c.

Wellman-Seaver & Head, Ltd.

Controllers.

The illustrations herewith show some examples of a line of electric controllers which well merit the attention of power engineers. The most important features of these controllers are: Firstly, that they are self-contained, *i.e.* the resistances and controller are embodied in one frame; secondly, that the method of operation is a simple straightforward to-and-fro motion of a lever, which the makers rightly state that long experience with their well-known charging machinery has proved far less tiring to the arm of the operator than the ordinary tramway type, and also that when a man has more than one controller to work rapidly he can

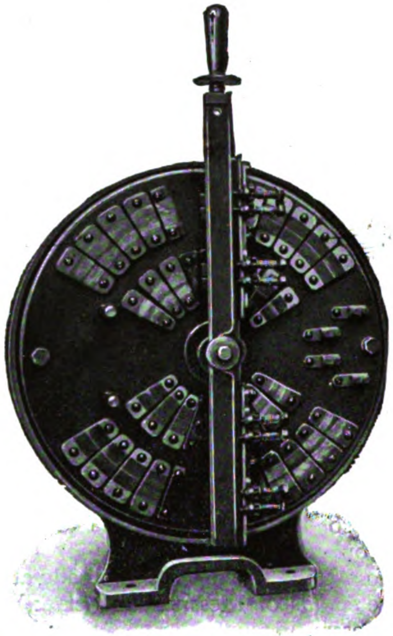


FIG. 2. SMALL-POWER "DINKEY" CONTROLLER. UP TO 20H.P.

pass from one to the other much more readily with this method of operation.

Again, as these controllers were originally designed for use on steel works charging machinery, they are made of very ample scantlings, and each part which is subject to

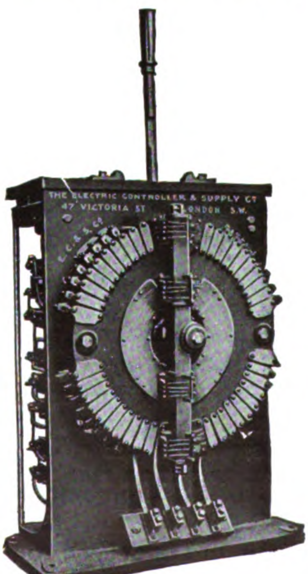


FIG. 1. HEAVY-POWER "DINKEY" CONTROLLER. UP TO 350H.P.

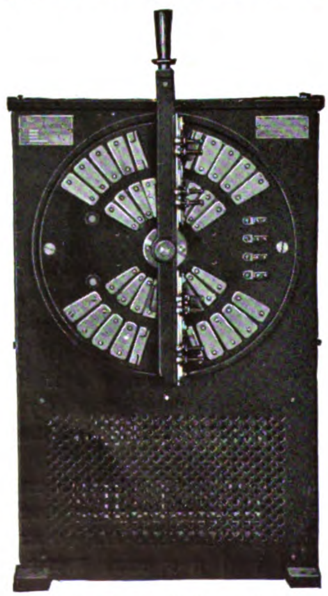


FIG. 3. MEDIUM-POWER "DINKEY" CONTROLLER. UP TO 100H.P.

wear is designed so that it can be renewed when necessary in a very few minutes. This is a matter of great importance in apparatus of this description, when, as a rule, the time for paying attention to the upkeep of machinery is very limited and reliability is essential.

The resistances are either of the cast-grid or coil type, whilst either can be usually supplied, according to the customer's preference; in some of the controllers for very large horse powers with high voltages the coil type only can be used. These coils are of very special design and of high insulation. In the "U" type controller the resistance coil also forms the magnetic blow-out for the particular stop of the controller to which it is attached.

All these controllers can be fitted with spring return, water-tight covers, rheostatic breaking points, &c., according to the requirements of each case.

The London Decorative Metal Works, Ltd.

Art in Electric Fittings and Furniture.

It has been said that the artistic instincts of a nation must be judged not by the treasures of its museums and art galleries, but by the beauty of form displayed in the humblest articles of domestic use—by its jugs, its cups, and its spoons. The exhibit of the London Decorative Metal Works, Ltd., well illustrates how much simple beauty can be put into the small accessories of an electric lighting scheme and how much the harmony of its general effect will be enhanced if proper attention is paid to the choice of what many people wrongly look upon as unessential details. This firm's striking and well-arranged showcase in the reception room of the Metropolitan Electric Supply Companies contains a varied assortment of ornamental switch-plates, plug-plates, domes, bell-pushes, with, in many cases, lock and finger plates and door handles all designed *en suite* to match.

Taking advantage of the growing weariness of the cultured public of the horrible later developments of the "art nouveau," the London Decorative Metal Works are reverting to the chaste and restful Old English styles, and to the elegant but more elaborate French designs of the Louis and Empire periods. There is an idea common in some quarters that well-designed, carefully executed and highly finished metal-work can only be obtained in France or Belgium. It is whispered that much of the so-called highly-chased French work is manufactured in this country; but apart from this rumoured fact, the exhibit under notice proves there is still craftsmanship in England that need not be ashamed of.

The Adam and Georgian suites exhibited are finished in a soft antique silver, the former including a large lock-plate and handsome switch-plates, designed to cover a large number of points. The plates in the French styles are finished in a rich old ormolu gilt which shows up the fine chasing of a large six-way Louis XVI. switch-plate and of a series of Empire plates and door furniture with massive laurel-leaf borders to particularly good advantage.

This firm is also showing some cheaper forms of switch-plates, consisting merely of a plain tooled or matted centre, surrounded by neat chased borders; but simple as these designs are, the general appearance and finish of the plates are such as to remove them entirely from the category of the ordinary cheap plate which is made by stamping. The advent of really attractive flush switch-plates to suit all requirements is bound to popularize the use of sunk switches, and to hasten the advent of the day when a well-furnished room is no longer bound to be disfigured by the unnecessarily obtrusive surface switch, the gaunt ugliness of which is usually accentuated by the ordinary fluted dome finished in a conspicuously brazen brass, and whose chief delight seems to be to strike the note of discord in whatever scheme it may happen to be associated with.

Berry, Skinner & Co.

Switches and Distributing Boards.

Throughout the Exhibition the distribution boards are of one type; the service mains into the buildings terminate in cast-iron sealing boxes, immediately above which are placed the main switches, the boxes and switches being assembled, as will be seen in Fig. 1, to form an iron-enclosed unit. The boxes and switches are of the well-known Berry-Skinner types. The latter are of the ironclad form, having the switch and fuse terminals mounted on the inside of the lid

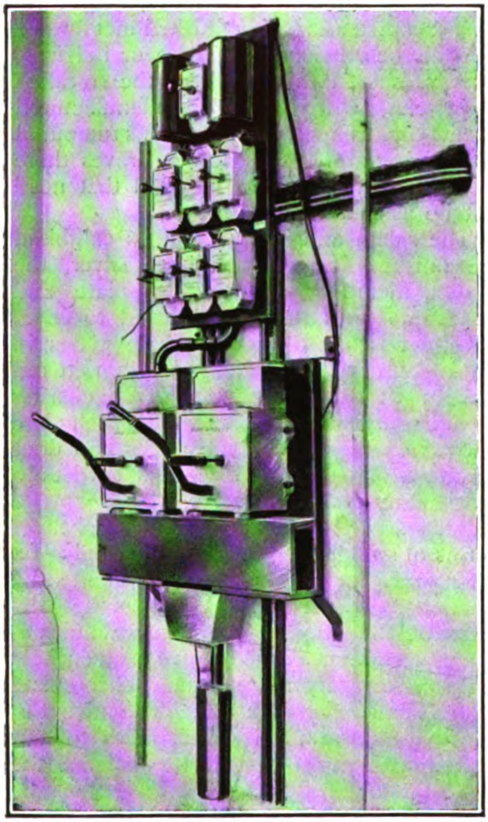


Fig. 1. Berry-Skinner Distribution Board.

or cover, so that in the event of inspection of the switch or replacing of the fuses being necessary, the opening of the lid swings the switch parts and fuse terminals clear of the live contacts and renders them perfectly "dead" and easily accessible. The first illustration shows a typical board consisting of the sealing-box, two main switches and a series of seven sub-circuit arc lighting switches. The boards are of slate supported on wrought-iron saddles a little distance from the wall. All conductors on the front of the board are completely encased in metal, the live ends emerging only inside the iron cases of the switches; rear connections are amply protected also, but are yet free for inspection in the space behind the panel. Fig. 2 shows a group of eight of these Berry-Skinner switches arranged on a board in conjunction with an enclosed pair of bus bars between the two rows. There are a large number of such boards distributed throughout the Exhibition, and the attention of engineers is directed to an arrangement which is so obviously safe and effective.

The Linolite Company.

Tubolite Lamps and Fittings.

The Linolite Company are showing on their stand in the electrical companies' combined exhibit samples of their well-known "Tubolite" fittings for shop windows, churches, and the lighting of rooms by reflection from the ceiling. The fitting is a practically continuous straight line of incandescent carbon filament of the usual and well-tried type. The filament is contained in lengths of about 8½in. in straight glass tubes, ⅞in. in diameter, having one terminal at each end. The standard lamp is 12c.p. (more would be wasteful on account of the efficiency of the system), taking 3.75 watts per c.p., and has an average life of 1000 hours, with a decrease of only 14.5 per cent. of the light in that time.

The lamps are placed end to end in a semi-circular, channel-shaped, highly polished aluminium reflector, 2¼in. wide by 1in. deep, having an efficiency of 81 per cent., compared with 92 per cent., the efficiency of highly polished silver, the most nearly perfect (though too expensive) reflector there is. The two edges of the reflector are rolled into small beads, each of which carries the wires, which are thus protected from injury. The lamps are held firmly and in the position for maximum efficiency in the reflector by aluminium holders, having centre contact plungers.

The Linolite Company also show several new patterns, and amongst these should be specially noticed those fitted with porcelain holders in place of the aluminium ones above referred to. These new holders enable the company to supply patterns equal in efficiency to their previous patterns at a much lower cost, and from an electrical point of view the porcelain holders are a decided improvement. A special large reflector for use with 32c.p. lamps is also on show, and this is fitted with a large type of the new porcelain holders. Several neat forms of desk fittings occupy the centre of the stand, together with a specimen of what can be done in the way of illuminating transparencies. A special feature of the exhibit is that all samples shown are clearly

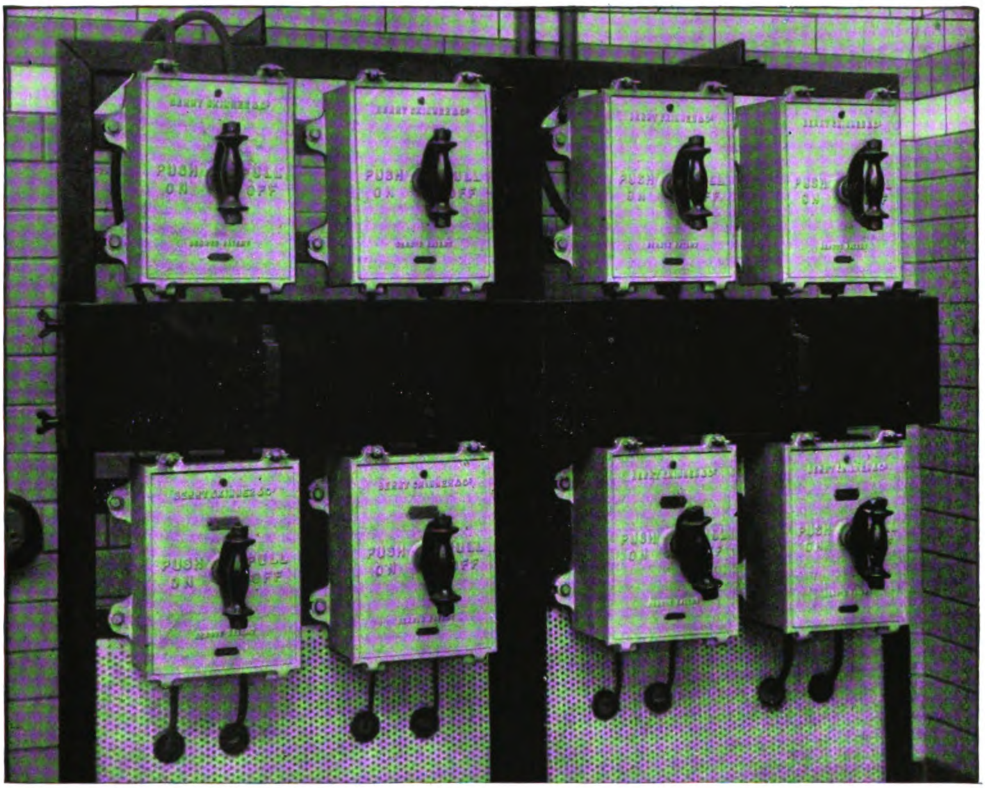


FIG. 2. GROUP OF EIGHT BERRY-SKINNER SWITCHES.

marked with their price and special use, both in French and English, the prices being quoted in shillings per foot, and in francs per metre.

The Dowsing Radiant Heat Co., Ltd.

Electro-Medical Appliances.

That electricity is making rapid strides in the direction of curative applications cannot be gainsaid, but its real advance and actual results obtained can only be known to the few.

Like all other scientific applications—after the early stages are passed—it must be specialised, and many medical men are now giving the subject of electrical treatments their undivided attention, with immense advantage to the public at large.

Not more than ten or twelve years ago, the "battery" was the only electrical application of any importance, but this is now the smallest, and is in many respects the least important of electro-medical appliances of the present day.

The powerful currents of electricity now employed, and the knowledge gained of their action, have placed electrical treatments in an altogether different category from the doubtful applications of former times, when the battery was used mostly for neurotic cases, and, of course, it was a sure cure where there was no disease.

With the Rontgen ray apparatus, high frequency, various forms of hydro-electric applications, and electricity used for the radiant heat and light treatment and Finsen applications, we have very powerful and undoubtedly very perfect curative appliances of great possibilities.

These applications require a special knowledge on the part of the operator, both on account of the danger of dealing with heavy currents of electricity, and of risk in their application to the human body. The lack of such knowledge, especially in connection with X-ray apparatus, has led to disastrous

FIG. 1. ELECTRO-MEDICAL CABINET.

results, and many of the early operators, not knowing the dangers to which they were liable, exposed their limbs and bodies with direful results. When it is remembered that the earliest X-ray photographs required some thirty minutes' exposure, and the present tubes will produce better skiographs in twenty seconds, an idea of the great advance made in this direction may be conceived.

Formerly the tubes employed emitted rays in many directions, but it is absolutely essential that a covering of lead foil or glass should be used to protect the operator from their dangers. There is no harm to the patient, who is only subjected to the rays for a few seconds at a time, but it cannot be too strongly urged that amateurs who do not know the risks incurred should refrain from exposing themselves or their friends to the extreme

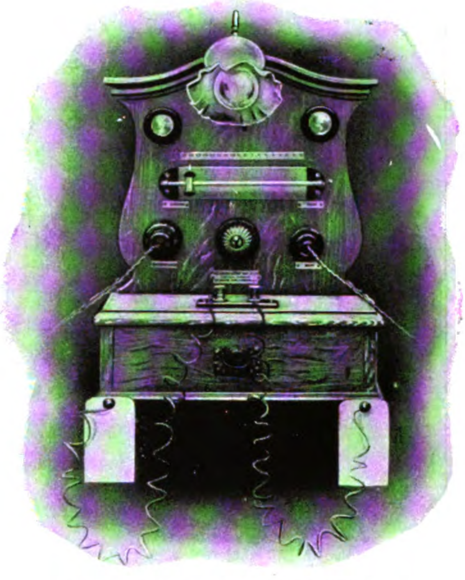


FIG. 2. ELECTRO-MEDICAL CABINET.

danger of powerful X-rays. On account of the destructive action of these rays, they are used in the treatment of various diseases where the destruction of tissue or microbic life is desired. Thus lupus, which is treated superficially by Finsen light rays,

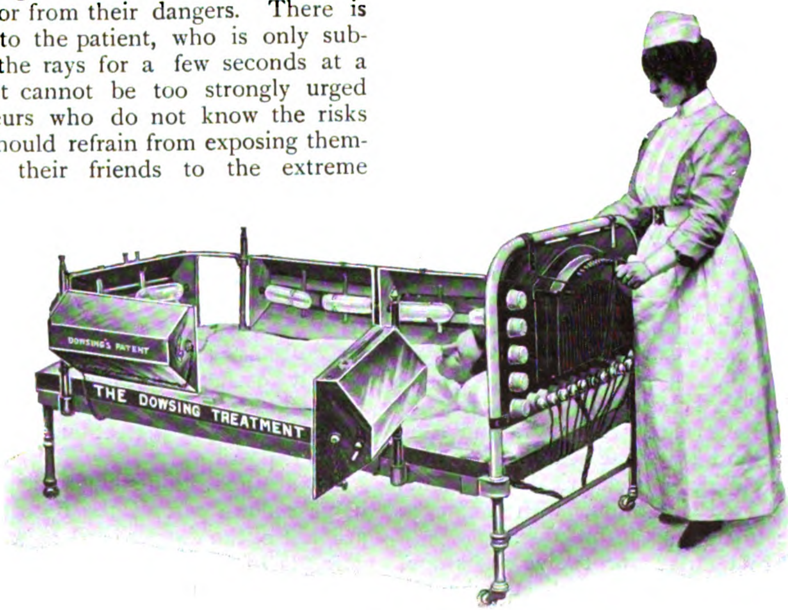


FIG. 3. RADIANT HEAT BED.

is only reached when deeply seated, by X-rays.

The induction coils employed are far more effective and reliable, and the mercury jet breaks much more efficient. With regard to the latter, the latest improvement appears to be the breaking of the current in an atmosphere of ordinary coal gas, with which the jar is filled. This prevents oxidation, and considerable savings are effected in the amount of mercury used in the apparatus.

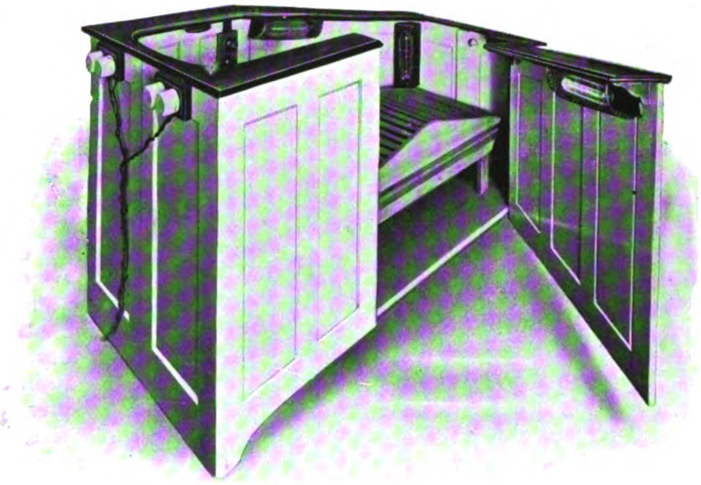


FIG. 4. ELECTRIC SUN BATH FOR HOME USE.

On Stand No. 49 in the Machinery Hall (British section) a large number of electro-medical appliances of the latest types are exhibited by the Dowsing Radiant Heat Company, of 24, Budge Row, E.C. Most of the appliances are connected to the circuit, and may be seen in operation.

The X-ray outfit manufactured by Messrs. Cox & Co., Ltd., is of the latest pattern, and of a very powerful description. With it,

FIG. 5. HYDRO-ELECTRIC CHAIR.

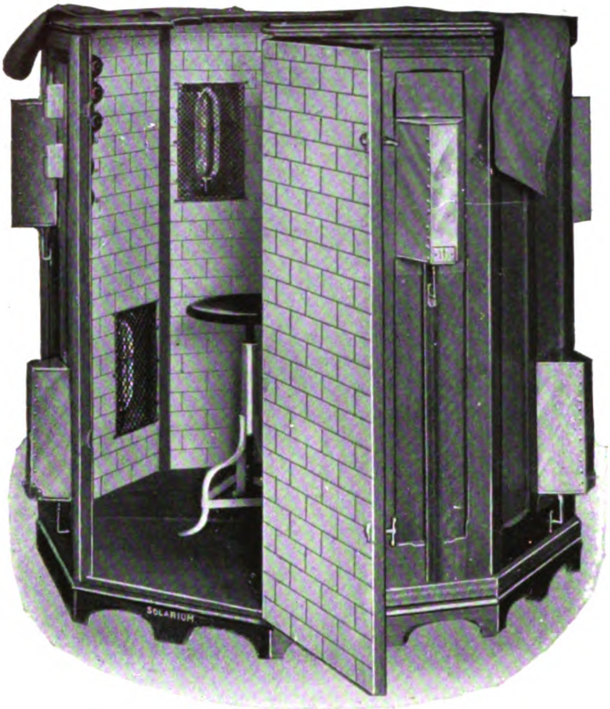


FIG. 6. ELECTRIC SUN BATH. INSTITUTION TYPE.

The Dowsing radiant heat and light treatment is illustrated by means of a complete radiant heat bed, in which the whole body (with the exception of the head) is treated (Fig. 3).

This system of treatment, which is only given under medical prescription, is now a part of the equipment of most of the up-to-date hydros and other similar establishments and institutions, and its success has been very great. These appliances are in use in 121 establishments spread throughout the British Isles, Europe, and America, and they are used for treating gout, rheumatism, sciatica, lumbago, sprain and similar troubles.

It is not, of course, a direct electrical application, electricity being used to produce light and heat rays, which penetrate the body and effect the results desired. It was the first of the "ray" treatments, Finsen's rays being introduced some time afterwards.

every bone in the body can be found, and the heart seen to beat. The tube is carefully protected with ebonite and lead-glass covering, and the new gas-break is employed.

The Mackenzie-Davidson localiser is shown, and there is an illustration of a portable appliance as used on the battlefield, the whole making a very effective and highly complete X-ray outfit, and with resonators and other additions, a high-class high-frequency equipment.

The hydro-electric applications are illustrated by means of switch-boards and cabinets (see Figs. 1 and 2), which are so fitted that current from the main electric supply can be used of any voltage, direct or alternating, and of any periodicity. The regulation is shown to be most perfect, and the cabinet (Fig. 1) is fitted for giving constant, Faradic and sinusoidal treatments.

The hydro-electric chair (Fig. 5) is an improved arrangement for giving local electrical treatments, and passing currents of electricity through the body. In this way the current through the patient may be measured, and the whole application is very simple.

A modification of this system is the solarium or electric sun bath (see Figs. 4 and 6), in which there is a similar application of luminous heat rays, but the proportion of the one to the other is very different. In the former case, a large predominance of heat rays of a certain low specific luminosity is ensured, but in the latter, more light than heat rays are introduced, the object being to produce a profuse perspiration with a comparatively low degree of heat. It is now a well-established fact that the skin will act more freely with luminous than with non-luminous heat, and with heat rays rather than hot air. The difference is most important, and the effect on the person taking the application most marked. The lassitude usually following hot-air applications is absent in the great majority of cases treated by means of luminous heat rays.

It should be borne in mind that the general use of such electric-light baths in the home would be a most important factor in the demand for electricity, and electric light companies should foster their use. It is found that from one to two units (cost, 1d. to 2d.) is sufficient to get a most excellent electric-light bath.

Machine Tools, Workshop Appliances, &c.

Joshua Buckton & Co., Ltd.

Planing Machine.

Of the many machine tools shown in operation one of the most noteworthy is the Patent Regenerative Spring-balanced Planing Machine of this firm. The principle of the machine is that of balancing the forces by large recoil springs which are, in fact, large enough to absorb the whole energy of the parts that move and have to be reversed; these springs restore during the moments of acceleration the energy which would otherwise be wasted. These springs produce beneficial results other than the large saving of power that they effect. Much time is saved by the promptitude with which the machine reverses and attains its full speed. The reversal is extremely accurate; although the machine may be cutting at 60ft. and returning at 180ft. not more than $\frac{1}{8}$in. clearance is required between the tool and any projection above the surface being planed. This accuracy is obtained without having regard to modification either of stroke or cut.

The two springs abut each against one of the cross bars of the bed or gantry; screws pass through these springs and lie along the whole length of the bed. Heavy bronze nuts are adjustable on these screws, and knockers attached in fixed position to the underside of the moving table impinge on these nuts. Any length and position of stroke is obtained by altering the position of the nuts upon the screws by turning the latter. The length of stroke is adjustable down to 12in.

The stroke may be adjusted while the machine is running. Such adjustments do not disturb the synchronism of the belt-striking motion with the spring compression. The return stroke takes place at the constant speed of 180ft. per minute; the cutting

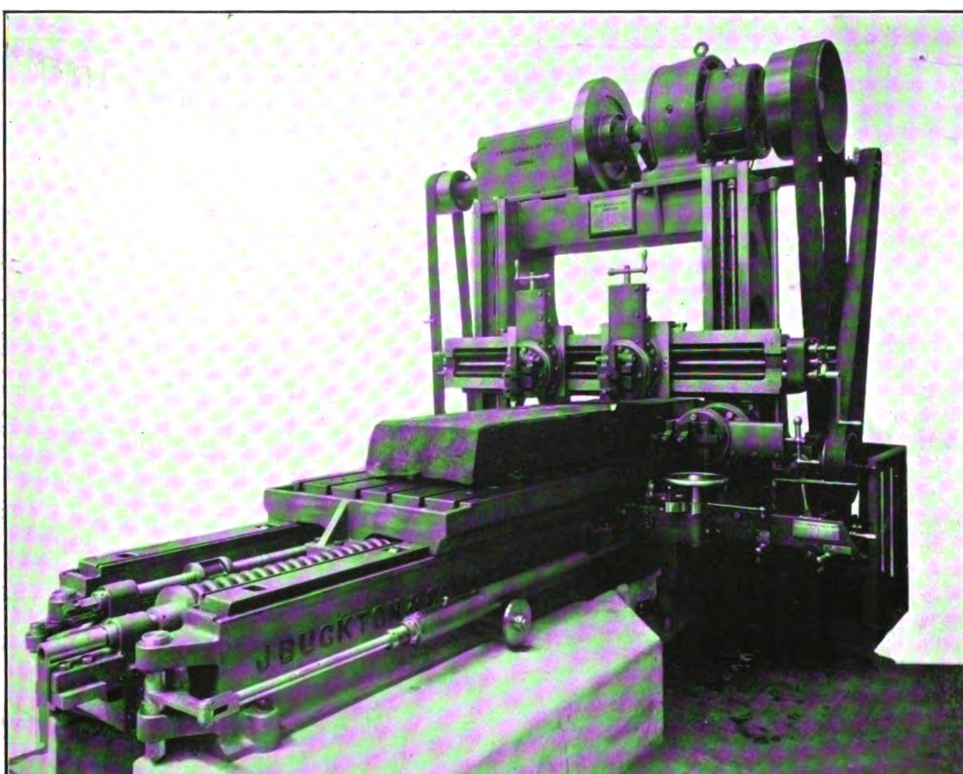


Fig. 1. Regenerative Spring-balanced Planer. Joshua Buckton & Co., Ltd.

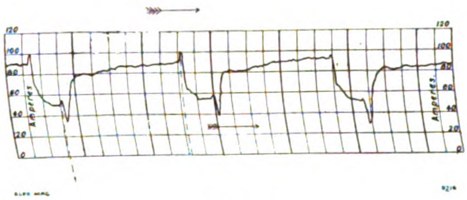


FIG. 2.

stroke of the machine may be varied through change speed gearing, but although the total range of speed, *i.e.*, from 20ft. to 180ft., is in the ratio of 9 to 1, yet no adjustment is necessary throughout this range, and there is no difference in the accuracy of reversal.

It should be further mentioned that the machine carries a special power feed and traverse mechanism, arranged to give transverse and vertical feeds to the cross slide

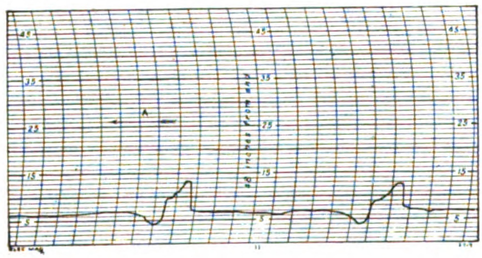


FIG. 3.

tool boxes, and vertical feeds to the side tool box. This mechanism also gives facility for rapidly traversing any of the boxes in any of their automatic motions, and for raising and lowering the cross slide by power, thus allowing the tool boxes and cross slide to be set for different pieces of work with the greatest ease and rapidity.

Should the machine be driven by an electric motor whose full load output is absorbed by the maximum cut permissible, then the machine will not impose an overload

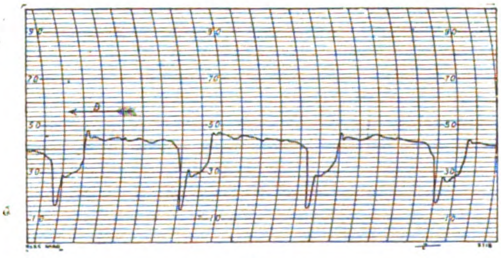


FIG. 4.

at the moment of reversal, the nett result during maximum cuts being a good load factor.

The machine shown at the Exhibition is one of the 10ft. × 4ft. × 4ft. size, driven by a 20h.p. Laurence Scott interpole motor. The motor runs at a constant speed of 600r.p.m., and is coupled direct to the driving gear head, as will be seen from the illustration. The motor is controlled by a ratchet type starter and dockyard panel fitted with modern magnetic blow-out switches by Bray, Markham, and Reiss. In the main circuit of the motor is connected a Kelvin and White recording ammeter, and this proves the claims of Messrs. Buckton with regard to the load-equalising and economy of the recoil spring design. The ammeter diagram, Fig. 2, and the records, Figs. 3 and 4, show very plainly the great effect produced by the regenerative springs. The records read from right to left, diagram Fig. 3 being taken with a light cut which shows a negative peak at reversal at one end and a positive peak at the other, and

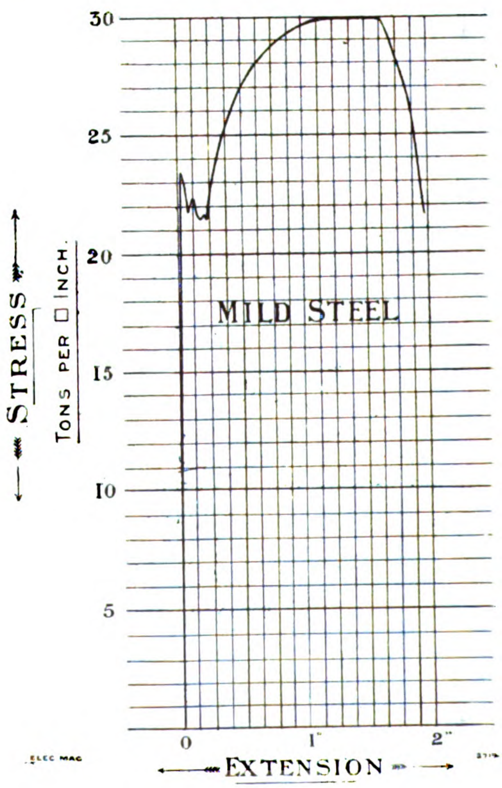


FIG. 5.

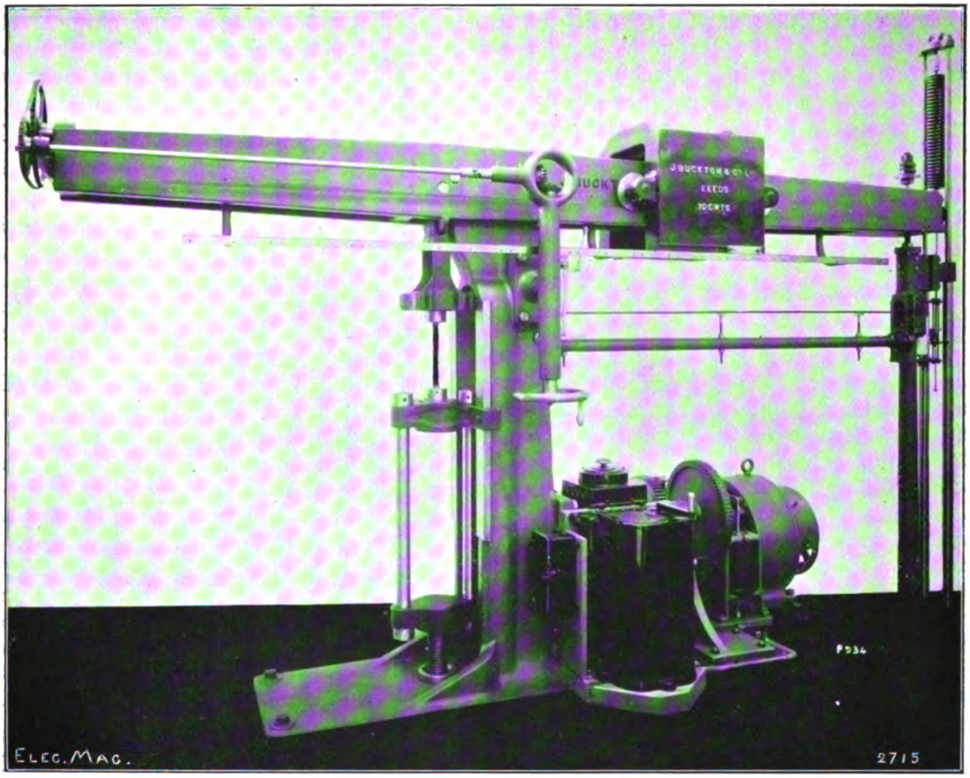


FIG. 6. 30-TON TESTING MACHINE, ELECTRICALLY DRIVEN AND FITTED WITH RECORDING APPARATUS. JOSHUA BUCKTON & CO., LTD.

diagram Fig. 4 with a heavy cut which shows negative peak at one reversal, whilst the positive peak at the other reversal disappears as it is merged into and does not exceed the load required for the cut. It should be noted that in Fig. 3 the ampere readings shown on the scale are to be multiplied by four and in Fig. 4 by two to give the absolute values of current.

Stress and Strain Recorder.

A remarkable improvement in testing machines is also shown by Messrs. Buckton. This is a new attachment here shown for the first time and consisting of Patent Autographic Stress and Strain Recording Apparatus fitted to a 30-ton vertical single-lever testing machine. The system exhibited forms a new departure, inasmuch as the poise weight of the testing machine is stationary, and is balanced by a spring which puts the whole steelyard into perfectly sensitive, though stable, equilibrium, and no records appear upon the stress strain curves which can possibly be attributed to the dynamic effects of a moving poise. The whole operation is automatic and entirely independent of the operator, whilst an exact record is obtained right up to the point of fracture; the yield point and the maximum load, the amount of stretched maximum load, and the amount of stretch due to local elongation, are all made visible. The illustration Fig. 6 shows this machine complete, whilst Fig. 5 shows a specimen diagram taken by the new recording attachment. The action of the electric motor will be gathered from the illustration; it is a 5h.p. 500-volt shunt wound machine by Laurence, Scott & Co., fitted with interpoles, and designed for variable speed, working from 360r.p.m. to 900r.p.m. with shunt regulation only. The starting and regulating apparatus are of exceptionally liberal design. The first speed reduction from the motor spindle is a 4 : 1 by Renold's chain, then there is a 16 : 1

spur reduction followed by a double worm and wheel reduction, each of ratio 80 : 60, to the main nut of the test rod. This new arrangement of testing machine permits of remarkable ease and delicacy of control, and is capable of use over a wide range, for which purpose a series of calibrated springs are provided for use with the recording apparatus.

John Stirk & Sons, Ltd.

High-speed Lathe.

This well-known Halifax firm exhibits a series of their electrically-driven self-contained machine tools, which have of late come into considerable favour and prominence. The 10in. centre high-speed lathe, self-acting, sliding, surfacing, and screw-cutting, is electrically driven by a 30h.p. motor and is fitted with sixteen gear changes giving a range of spindle speeds from 10r.p.m. to 250r.p.m. in fine gradation. Two handles operate the changes, and by the gate arrangement used it is impossible to put two into gear at the same time. The headstock and bed are cast in one piece, ensuring the greatest possible rigidity, and the lathe all through is built on the most ample proportions, so that the heaviest possible cuts do not appear to make any impression on the rigidity of the machine. All the gearing is of forged steel and machine-cut. The quick-running shafts have ring oiling bearings, and there is an improved friction clutch arrangement allowing the machine to be stopped without stopping the motor. This is useful in measuring work, changing tool, &c. The lathe complete weighs about seven tons, and is capable of taking a cut in .3 carbon steel $\frac{5}{8}$in. deep, $\frac{1}{8}$in. feed, at 70ft. per minute.

Vertical Boring and Turning Mill.

The 48in. vertical boring and turning mill is driven by a direct attached 13h.p. motor. Two tool posts are provided, each with swivelling slide and counterbalance arrangement. Independent self-acting positive feeds are fitted for each head, giving nine changes of feed in any direction. The drive is by gear-box giving eighteen changes of speed, and the final motion to the table is by multiple thread-worm. This is a special feature of the tool, ensuring perfectly steady drive, and, as is to be seen from the finished work being turned out, a total absence of chatter.

The table revolves in a bearing of anti-friction metal and the worm and wheel work in a bath of oil. The table speeds are approximately 1r.p.m. to 50r.p.m., and the approximate nett weight of the machine with its motor is about seven and a half tons.

High-speed Radial Drilling Machine.

This machine has been specially designed to enable the very best high-speed drills that can be obtained to be used to the utmost advantage. It is driven by a 13h.p. direct attached motor.

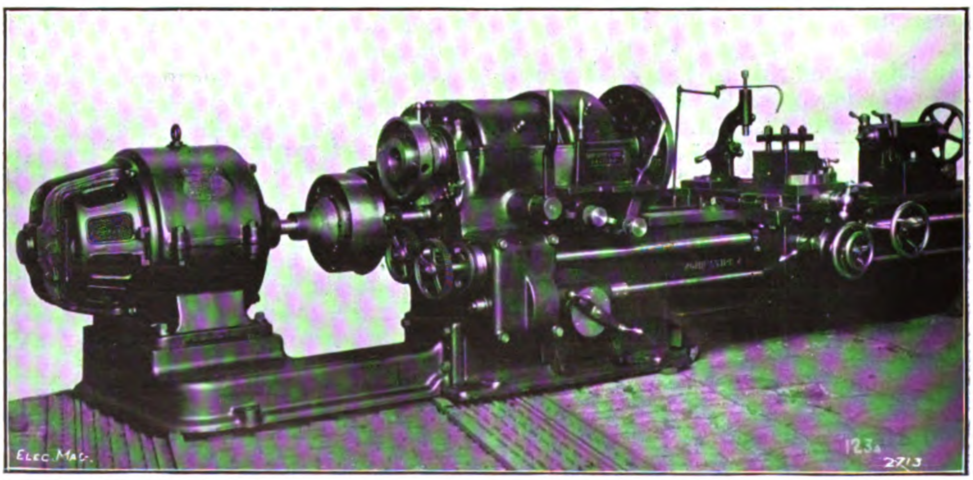


Fig. 1. Electrically-driven High-speed Lathe. John Stirk & Sons, Ltd.

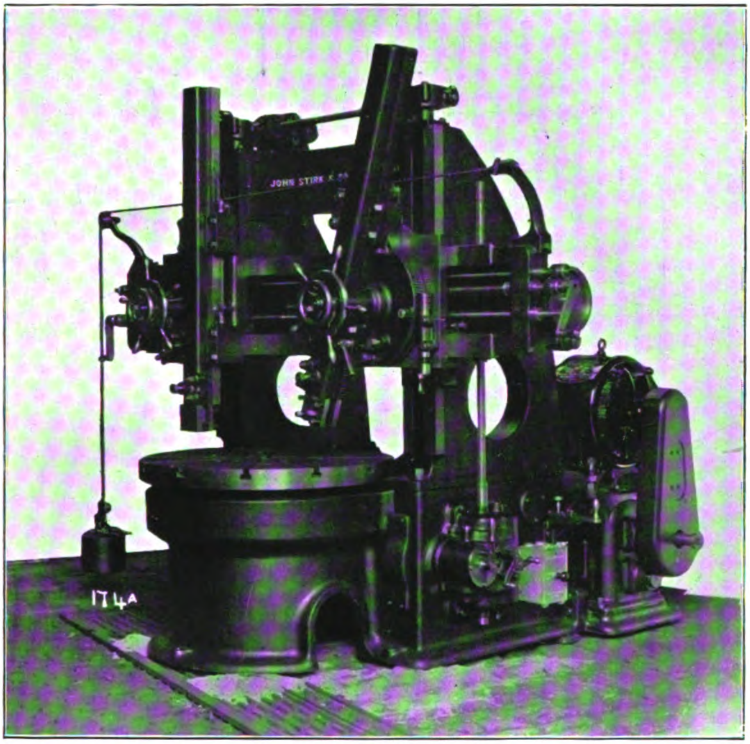


FIG. 2. ELECTRICALLY-DRIVEN VERTICAL BORING AND TURNING MILL. JOHN STIRK & SONS, LTD.

The arm is exceptionally strong, and can be swung on a pillar of large diameter in a complete circle. When in its lowest position it rests on steel balls, but it can be raised 12in. when required. The carriage is firmly gibbed to the arm, and is moved along by rack and pinion. An effective-locking device is provided within easy reach. The spindle is ground perfectly true, and is fitted with reversing motion for tapping, and carefully balanced. It has variable power feeds, quick hand movement for withdrawing drill, tapping, &c., and a slow hand feed. Morse taper or straight hole is provided as required.

The reversing motion (patent applied for) consists of a combination friction and positive clutch, and is particularly effective, enabling the spindle to be reversed with great facility. The drive is by gear-box giving nine changes of speed, which can be operated without stopping the machine. A double gear on the carriage makes eighteen speeds in all, from 13r.p.m. to 560r.p.m. The gear-box forms an oil bath for the gears, and the quick running shafts are made self-oiling, thus securing immunity from trouble through heating of journals, &c.

All handles for reversing, feeding, changing speeds, &c., are conveniently placed, and no spanners are required. All gearing is machine-cut from the solid. Mitre wheels are of steel, also spur pinions. The machine is guaranteed to drill 1in. holes in mild steel at the rate of 8in. per minute, and has been tested beyond this figure. The approximate weight of the machine with its motor is five tons.

Lathe.

In addition to the foregoing, Messrs. Stirk & Sons exhibit one of their ordinary pattern cone driven lathes with self-acting, sliding, surfacing, and screw-cutting motions. This lathe is fitted with quick-change feed to backshaft, and has all gears machine-cut. It is a very suitable lathe for general purposes, and will work at the highest speeds on moderate cuts.

Alfred Herbert, Limited.

The above firm has one of the most extensive and attractive exhibits of machine tools, all of which are shown in operation, producing actual work.

Lathes.

The No. 17 Combination Turret Lathe with patent chasing saddle is suitable for the heaviest type of chuck work up to 20in. diameter. The machine shown is equipped with an outfit of tools for producing a cast-iron special-valve cover plate which shows in a remarkable degree the advantages possessed by this type of lathe over the ordinary centre lathe, the surfacing and boring lathe,

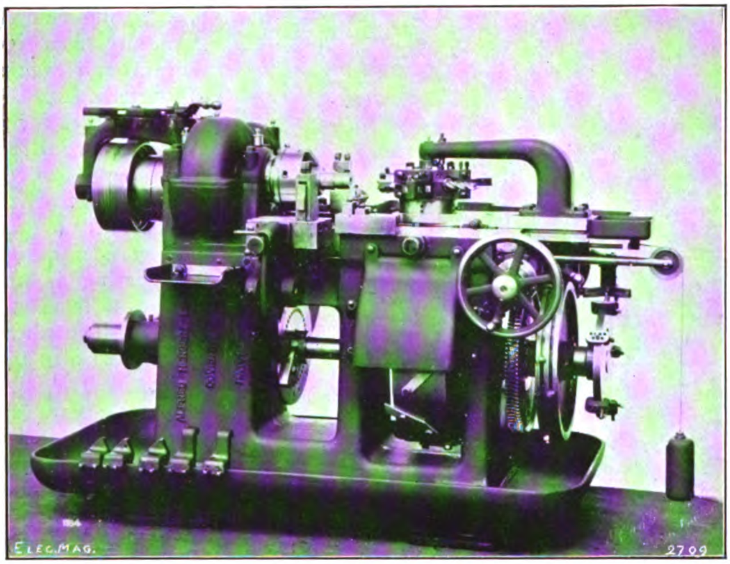


FIG. 1. AUTOMATIC TURNING MACHINE. ALFRED HERBERT, LTD.

or the vertical boring and turning mill. The speed and accuracy with which threads can be cut by means of the patent chasing saddle is also to be noted. The machine has a $5\frac{3}{4}$in. hole through the spindle, so that when necessary large bars can be conveniently handled.

The No. 5 Capstan Lathe, with patent chasing saddle, is fitted with the Herbert patent single pulley head, which may be driven direct from the line shaft, and gives sixteen spindle speeds, any of which may be quickly obtained. The machine is shown in operation on a casting similar to that being machined on the large lathe, and the adaptability of the tool outfit will be appreciated, as it enables a very large range of work to be handled with the one set of tools.

The No. 4 Capstan Lathe is a smaller machine of similar type to the foregoing and is shown in operation on a cast-iron commutator bush, the value of the patent chasing saddle being again apparent.

Another type of lathe exhibited is a $2\frac{1}{4}$in. by 30in. Patent Hexagon Turret Lathe shown producing work from the bar. This machine is fitted with the firm's well-known "Roller Steady Turning Tool," by which a 2in. bar of 30-ton steel can be reduced to 1in. diameter at a feed of 6in. per minute, leaving a true, smooth, and parallel job. This lathe will be found of special interest, as it is designed for producing direct from the bar screws, studs, spindles, lock-nuts, pulleys, and other similar articles, which form a large part of the product of nearly all engineering establishments. Owing to the speed at which work is turned out, and the ease with which the machine may be changed over, it pays to make either one or two pieces or a large number at each setting of the tools, and this feature will be recognised as of special value. It should be mentioned that this type of lathe is Messrs. Herbert's speciality, to which they have devoted a large amount of attention for the past ten years, and in its modern form the machine merits careful consideration.

Screw Machine.

The No. 10 Automatic Screw Machine is a smaller size of the firm's large line of automatics, and is here shown in operation producing a very involved and difficult piece of work from brass bar. The article is a stud or button with a hexagon end, each face of the hexagon being drilled with a fine hole; the centre is bored away, and the front has the firm's name rolled on. The job represents in miniature a hexagon turret, and is an example of what may be done on an automatic by an ingenious tool designer.

Automatic Turning Machine.

This is a new line of tools (see Fig. 1), designed for handling in the most economical manner detached pieces; that is to say, articles made from castings, forgings, or blanks sawn from the bar.

All the operations except the actual chucking proceed automatically, and when finished the machine stops and the operator removes the finished piece, puts a casting in the chuck, and starts the machine up again. In this way four to six machines can be looked after by one man with a corresponding reduction in the labour cost of the work

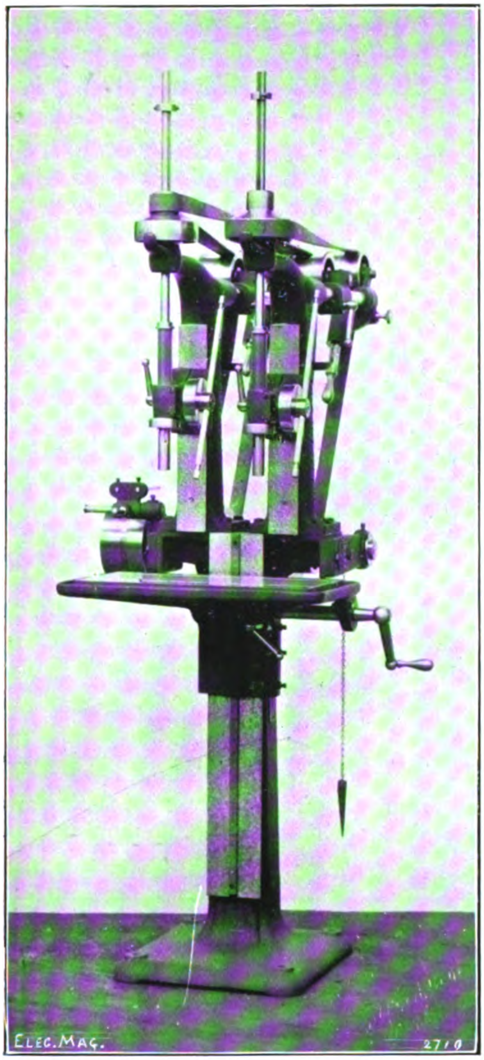


FIG. 2. NEW BALL-BEARING SENSITIVE DRILL.

produced. The patent self-selecting feed motion of this machine is a very ingenious device which enables any one of seven feeds to be obtained for any operation by simply placing a small screwed peg in one of the seven holes on each of the feed change dogs. By means of this feature one set of cams will make any article in the shortest possible time, thereby rendering it unnecessary to touch the cams when changing from one piece to another.

Ball-bearing Sensitive Drill.

This also is a recent introduction, being a two-spindle form of an entirely new range of sensitive drilling machines, here shown for the first time. All the bearings are fitted with balls, by which friction is reduced to such an extent that a $\frac{7}{8}$in. drill may be put through a cast-iron plate 1in. thick in five seconds, which is a very remarkable speed. This machine is illustrated in Fig. 2.

Gear Hobbing Machine.

This is a medium size of machine for generating spur gears by the hobbing process, which is now recognised as the correct method of producing accurate gearing, and has the further advantage of a continuous cut. The special features of this machine are the quick return to the cutter slide, and the very convenient feed motion. The feed is driven by the work table, and is changed to one of three rates by simply moving a small lever, no loose change gears being employed.

Worm Wheel Generator.

This is a machine which enables worm wheels of any lead to be accurately cut, using either a hob or a single cutter, which, when cutting, is in the same position as the worm which is to gear with the finished wheel; the fly-cutter or hob is fed into the worm wheel blank by being traversed across the blank on its own axis as it revolves. This special design enables worm wheels to be produced with great economy, even when only required in very small numbers. The position of the work enables it to be supported rigidly right up to its diameter, and is equally favourable for work of all sizes.

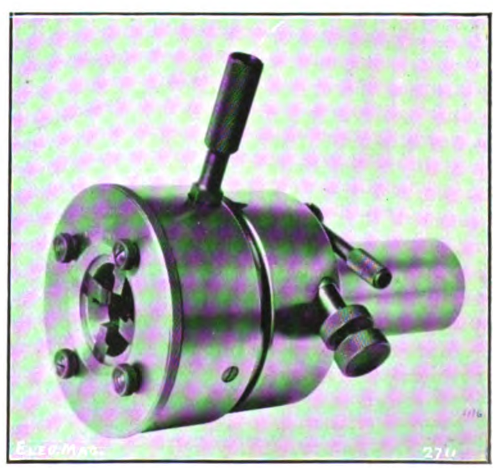


FIG. 3. SELF-OPENING DIE HEAD.

Self-Opening Die-Heads.

A special display is made of this well-known attachment, of which Fig. 3 shows a medium size. The Herbert patent straight-cut die has the advantage of enabling different diameters of threads to be cut by the same set of dies, using the adjustment to the die-head, and also of being sharpened on a disc grinder or other similar machine to constant angle, so that by means of a small grinding attachment dies may be sharpened by unskilled labour with a certainty of all dies in a set cutting alike.

United Flexible Metallic Tubing Company, Ltd.

All-metal Flexible Tubing.

In the "Palace of Machinery," Stand No. 679, will be found a very striking exhibit of the United Flexible Metallic Tubing Company's well-known speciality. The invention of a perfectly flexible tube composed entirely of metal is one of the most remarkable as it is valuable. Neither rubber nor textile or fibrous material entering into its structure, it is unique for the conveying of gas, water, oil, high-pressure steam and water, and in fact for all fluids. It is practically unaffected by heat or cold, remaining flexible at all temperatures.

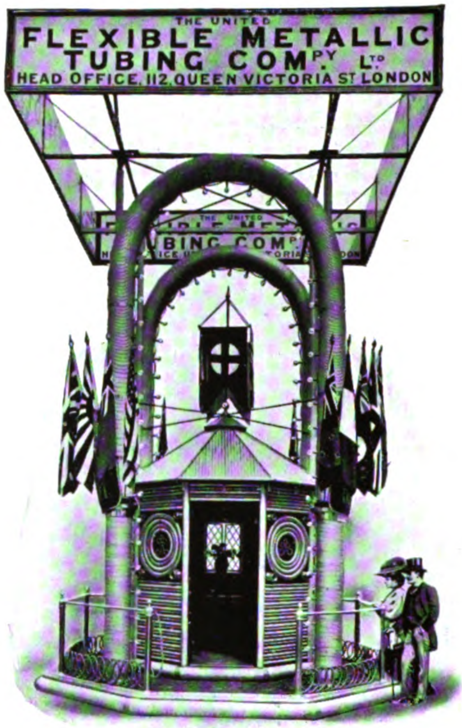


Fig. 1. The Stand of the United Flexible Metallic Tubing Company, Ltd.

The Company are contractors to the Admiralty, and supply their manufactures for use on H.M. ships, and in H.M. dockyards. Another use for this tubing is in connection with salvage operations, for which it is eminently suitable. Most of the great railway companies are using this tubing for a multiplicity of purposes.

For the conveyance of petroleum and other oils, or greasy liquids, which speedily attack rubber, this tubing gives the best results and has a life far surpassing any other kind of hose or flexible piping. The

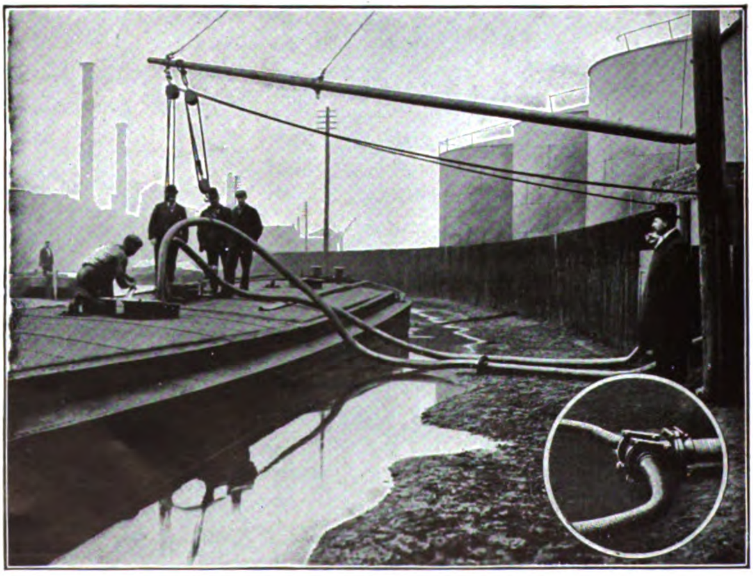


Fig. 2. Discharging Petroleum by United Flexible Metallic Tube.

illustration, Fig. 2, shows the tubing in use for the discharging of petroleum barges for which purpose it has been very widely adopted. Flexible metallic tubing is extensively employed by gas companies and by gas users throughout the world. As will be readily gathered the tubing is particularly suitable for production in special qualities for use under extremely high pressures, and in such forms it is made for services up to 2000lb. per square inch.

Hans Renold, Ltd.

Driving Chains.

As specialists in the manufacture of driving chains, which form their sole product, this firm shows a great variety of chains, chain wheels, cutters, &c. During recent years they claim to have supplied, annually, for general engineering purposes, drives to transmit over 30,000h.p. The exhibit includes patent silent chains, bush roller chains, block, stud, balance, textile, pipe wrench, and other special chains, as well as cycle chains. In several cases the parts of the chains are displayed separately, so as to show the construction.

The complete chain drives shown include sizes for powers ranging from 3h.p. to 40h.p., and speeds from 400ft. to 1300ft. per minute. In the silent chain drive is included a spring wheel, part of the cover of which is cut away to expose one of the springs. This special form of wheel is used for drives where the load is impulsive, as in pumps, compressors, forging machines, &c.

Photographs showing a few of the large number of purposes to which Renold chains are put form an interesting feature of the display.

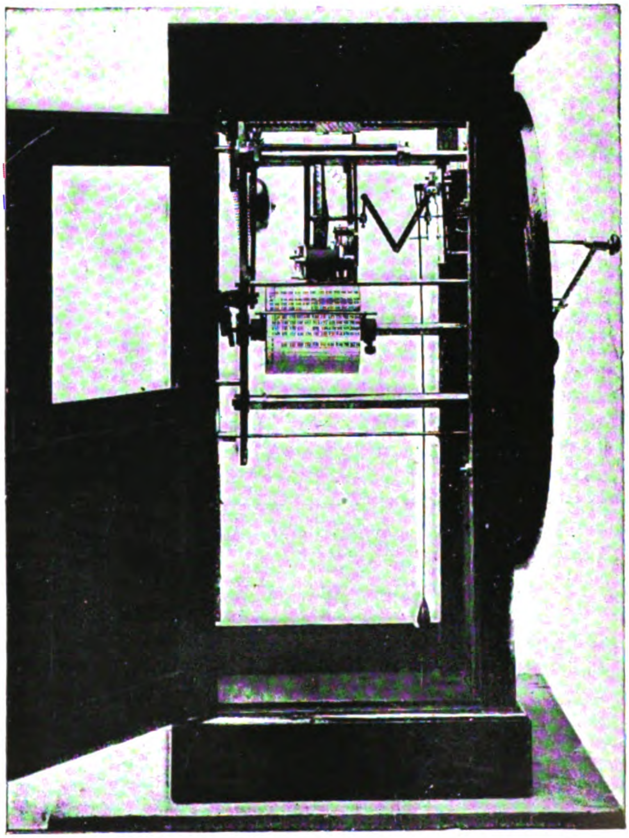
It is of interest to note that on the leaflet which is being distributed at the exhibition two drives are shown, each of which transmits 200h.p., making it evident that considerable powers can be satisfactorily transmitted by these chains.

The success of this firm, which was started by Mr. Hans Renold in 1879, in a very small way, is indicated by the fact that the floor space of the two works now measures over seven acres, and the number of employees reaches 700.

"Dey" Time Registers, Ltd. (Howard Bros.).

Time and Cost Keeping Machines.

At various centres throughout the Exhibition are distributed a number of "Dey" time registers. The use of clock machines for automatically recording the times of starting and leaving of workmen, indicating prominently the defaulters, has become very general in all classes of workshop. There are several types of these machines on the market, and of these it would be safe to say that the



THE "DEY" TIME REGISTER.

"Dey' register occupies a foremost position in this country. The particular merit claimed for this machine is its extreme simplicity both in its design and method of operation. As will be seen from the illustration, the internal parts are simple and few; no loose keys or checks are used by the workman in recording his time. This latter feature is particularly advantageous; the confusion and trouble which frequently arise where keys and checks are lost, misplaced, or wrongly used are well known to employers. The operating face of the machine is seen at the left-hand side of the illustration. The hand lever moves round a numbered dial. Simply pushing the pointer into the hole opposite the employee's number prints the time, and rings a bell to denote that the time has been properly registered. This is done so quickly that 2000 men can register their time on ten machines in four minutes.

It is a great advantage to those who are punctual to have it known that their records are good ones. For those who are not it will make them so. Where large numbers are employed the registers are placed in the different departments where the employees work, so that the record is made to the minute when they actually commence and finish work, thus saving the time occupied in getting from the time office to their respective shops or departments. The latest model is the Automatic machine, as shown in the illustration, which requires absolutely no attention for a whole week, the mechanism moving from "in" to "out" and from day to day automatically, it being only necessary to change the time-sheet once a week, wind up the clock, and wind back the recording mechanism to start the next week. Another recent improvement is a duplex ribbon attachment which automatically prints the time of late-comers in red ink, ordinary times being recorded in blue.

At the Exhibition these time registers are in use at the Flip-Flap, the Stadium, the Spiral Railway, the Uxbridge Road workmen's entrance, offices, &c., there being altogether nine machines for the use of the staff at the Exhibition. The machines are also used in their model factories by Messrs. J. Lyons & Co., Fullers, Ltd., McVitie & Price, Ltd., Caleys, Ltd.

Owing to rapidly-increasing business the makers of the "Dey" time registers have been compelled to seek more commodious premises, and have recently removed to 75, Queen Victoria Street, E.C.

F. Reddaway & Co., Ltd.

Belting, Conveyors, Hose, Rubber Goods, &c.

As will be seen from the illustrations, this firm has indeed made an exceptionally prominent display of their well-known specialities. The Reddaway Pavilion, situated in the gardens adjacent to the Palace of Machinery, is a handsome and attractive structure containing a splendidly arranged collection of what may be termed flexible engineering goods. The "Camel" brands of belting, known the world over, are manufactured for every variety of purpose. For power transmission, cotton belting, plain or treated with rubber compounds, is manufactured in all sizes up to those capable of transmitting several hundred horse-power. Messrs. Reddaway are celebrated for their invention of the now well-known "Camel Hair" Belting with which the name of this firm is synonymous. They have manufactured this belting for a good many years and it is still to-day considered the best for main and machine driving.

For conveyors Messrs. Reddaway manufacture rubber and cotton belts, and in their pavilion at the Exhibition is shown a 12in. belt-type conveyor in operation. Not only do the firm specialise in the manufacture of belts for conveyors, but they make the complete machines for every variety of purpose, these including not only the belt-type, but also steel-plate conveyors, bucket conveyors, spiral conveyors, those of the push-plate and drag-chain types, &c.

The "Sphincter" grip armoured hose is another speciality exhibited. This is a flexible hose armoured with a steel wire spiral, and is supplied for use with pressures up to 15,000lb. per square inch. It has been very widely adopted for pump services, for oils, acids and chemicals, hydraulic work, compressed air, &c.

Messrs. Reddaway & Co. have long been known as manufacturers of high-class rubber goods: these include beltings, packings, hose, tyres (solid and pneumatic), buffers, washers, rings, and in fact every well-known engineer's accessory and domestic appliance wherein rubber of high grade is required.

THE CAMEL PAVILION OF F. REDDAWAY & CO., LTD.

INTERIOR VIEW OF THE PAVILION, SHOWING THE WIDE RANGE OF MANUFACTURES

Enamel Insulation.

MESSRS. CONNOLLY BROTHERS, Ltd., the well-known cable makers of Manchester, have recently placed upon the market a speciality which is bound to receive great attention from electrical manufacturers and also contractors generally. It has long been felt that the substitution of an elastic coating applied in the form of a paint or enamel to electrical conductors for the usual cotton or silk textile coverings would be the source of large economy in the winding of electro-magnets and solenoids, and probably also in the way of cheapening the lighter classes of conductors such as are used for bell and signal circuits. There have consequently been many attempts made to produce an enamel-coated wire for general electrical purposes, but for one reason or another none of these has as yet made much headway in electrical practice. This pioneer work has, however, served as a guide to others engaged in the work of development, and Messrs. Connolly have made a thorough study of the various efforts that have hitherto been made to supply such goods, and are familiar with the causes of their comparative failure. It is said that thorough tests have justified the noteworthy claims made for these wires, and it would seem that the process, based upon a most important and recent discovery, has opened up a wide field of usefulness for enamelled goods for which the makers claim a reliability and durability hitherto unknown.

Most of the enamel coatings hitherto tried have been compounded more or less upon the principle of the oxidisation of linseed oil, or other oils in combination with gums, &c., that are hardened by exposure to air, either with or without the assistance of heat, very much in the same manner as ordinary house paints and varnishes and lacquers become hardened. The trouble with all enamels based upon this principle is that the oxidisation does not cease when it has reached the desired stage, but continues to develop indefinitely until the enamel is decomposed and breaks up. Another enamel-insulated wire has been produced by the use of a compound called tetra-acetate of nitro-cellulose; but the makers of the new enamel aver that the durability of such a coating is doubtful, as nitro-cellulose compound is notoriously unstable—this coating is also easily destroyed by weak alkaline or saline solutions.

The new enamel insulation does not depend upon oxidisation at all; it is said to be the result of a peculiar change or polymerisation of stearine pitch brought about as the result of a treatment in the process. This change is very analogous to that produced in the vulcanisation of india-rubber, but in this process no sulphur is used, and when the enamel is once fixed it becomes unalterable in its characteristic properties.

The following are among the special advantages claimed for Connolly's Patent Enamel:—

The enamel resists the action not only of acids and most other usual solvents, but also resists the action of alkalies, saline solutions, &c., whether cold or warm; it is also unaffected by immersion in melted paraffin or ozokerit wax, and in this respect probably stands alone among flexible enamels.

The covering is flexible, tough, and elastic, and it does not peel or shale off even with the sharpest bending.

The covering will stand without damage all the handling necessary in practice, and without fear of cracking the enamel.

The covering is a perfect substitute for silk and cotton coverings of electrical wires, and is superior to either of these materials, and is also a much thinner covering.

The enamel is waterproof and a good insulator.

The specific resistance is high, as is also the dielectric strength.

The enamel is not affected in any way by ordinary acids, salts, alkalies, alcohol, mineral oils, and by scarcely any of the ordinary solvents.

The enamel will support a very high temperature without melting or being otherwise damaged; for example, it will stand a temporary rise to 600deg. Fahrenheit, or a heat of 400deg. Fahrenheit for several hours, without being affected at all.

When subject to great heat the material does not melt, and it does not burst into flame even when the coated wire is at a red heat.

It is not affected by exposure to air or to light, and cannot be injured or altered by oxidisation as is the case with all other enamels.

The enamel is specially suitable for the protection of electrical fittings and accessories, such as lamp sockets, lamp holders, switch covers, and other metallic surfaces, and promises a useful field for development in this direction.

It will be seen that the new enamelled wire offers great advantages to the instrument maker in the saving in the space factor as compared with silk or cotton covered wires. Three coatings of enamel are used on the regular stock wires, and altogether add rather less than one-thousandth of an inch (0.025 m/m) to the diameter of the bare wire; finer coatings if required for special purposes can be applied with the utmost ease, and at a very slight increase in the cost. The following is a comparative example illustrating what this means:—

Three reels of exactly similar dimensions were wound with 22s.w.g. wire with the following results:—

		Weight. Gross ozs.	Nett ozs.
Double cotton-covered wire	33 × 7 = 231 turns...	3½ ...	2¾
Double silk-covered wire ...	38 × 9 = 342 turns...	5 ...	4¼
Enamel-insulated wire	52 × 12 = 624 turns...	8 ...	7¼

This advantage is of course intensified the finer the size of wire that is required to be used.

The covering is both tough and flexible, and will stand all the handling necessary for winding without fear of damage; coils of the smallest diameter required in practice may be wound without fear of cracking the enamel; for example, a No. 20s.w.g. may be wound in a close spiral around a No. 8s.w.g. wire with perfect safety to the enamel, and other sizes in proportion. The enamel will stretch evenly with the copper wire, and will remain unbroken until the copper is ruptured, but it is not claimed that the enamel has the same stretching powers as high-class india-rubber. The covering is thoroughly efficient as an insulator, being superior to either silk or cotton; its waterproof qualities and power of resisting a higher degree of heat than any fibrous covering will also be an advantage in many cases.

For the winding of arc lamp coils the above advantages also hold good, and in addition the fact that the enamel is not affected by exposure to light, to the atmosphere, to salt, alkaline or acid solutions, and is non-inflammable, offers further advantages.

In all cases where dynamo and motor windings are to be of fine wire the enamelled wires may be used with advantage, either plain enamelled or with cotton coverings where considered necessary. The space factor and the power of resisting heat, the toughness, flexibility, and unchangeable nature of the enamel are all features recommending it for this class of work. The makers are introducing a special line of wires, which are first coated with enamel, then cotton covered, the cotton being first desiccated and then impregnated with Voltalac, Major's Varnish, or any other suitable varnish that may be specified; such a covered wire may be confidently used where a cotton covering is preferred to act as a mechanical cushion between the turns of enamel-coated wire, and entirely obviates the necessity of stoving the finished apparatus. It is thus a distinct improvement on shellac-varnished cotton-covered dynamo wires. It is also to be noted that the new enamel-coated wires have been tested by being immersed for several weeks in insulating oil of a quality such as is generally used in transformers, and at a heat of about 180deg. Fahrenheit, and has been found after this period to be quite unaffected.

Another particular class of conductor where the enamel offers advantages is for the shot-firing wires in mines.

Messrs. Connolly are introducing a line of enamelled wires suitable for all classes of interior wiring in connection with bells and telephones, that are intended to take the place of the cotton-covered or india-rubber-covered bell wires that are in general use at present. The new wires are first

coated with enamel, and have then the usual textile coverings and finishes solely as a mechanical protection or padding, the enamel coating providing the sole insulation. It is guaranteed that these bell wires will stand a pressure of 100 volts direct current after 24 hours' immersion in water—a test which, the makers state, no other enamel known will withstand. It is therefore claimed in particular that these bell wires may be used in damp localities such as cellars, works, collieries, ships, and in many places where the much more expensive gutta-percha-covered, or vulcanised india-rubber-covered wires are now considered necessary, and, of course, they will compare very favourably in price with the ordinary pure india-rubber-covered bell wires in general use.

Finally, it is to be recorded of this most promising discovery that the enamel insulation being non-inflammable, there is no trouble in supplying wires with textile coverings that have also been rendered non-inflammable, and a perfectly fire-proof insulated conductor results.

New Catalogues.

Metallic-filament Lamps.—SIMPLEX CONDUITS, LTD., LONDON, W.C. Price list illustrating the new line of metallic-filament lamps introduced by this company, and also the special shades for use with them.

Cables, Fittings, and Accessories.—ELECTRICAL TRADES SUPPLY, LTD., BIRMINGHAM, send us sectional copies of their new list. These give illustrations and prices of standard lines of bitumen and rubber cables, mining type switches, and damp and dust proof fittings. The list also includes motor starters and electrical porcelain ware.

Lamp Transformers.—BRITISH ELECTRIC TRANSFORMER COMPANY, HAYES, MIDDLESEX. Illustrated leaflet describing the Berry patent auto-transformers for use with metallic-filament lamps.

Works Description.—CROMPTON & CO., LTD., SALISBURY HOUSE, E.C. This publication tells the story of Arc Works and its products, by a series of well-produced illustrations.

New Victoria Station.—LONDON, BRIGHTON AND SOUTH COAST RAILWAY. An artistic and well-illustrated book giving description of the new Victoria Station of this company.

Almanac.—W. T. GLOVER & CO., LTD., MANCHESTER, send us a copy of their latest almanac, covering the period from July 1st, 1908, to June 30th, 1909.

Electric Fans.—SUN ELECTRICAL COMPANY, LTD., LONDON, W.C. Complete illustrated price list, being Section D, catalogue number 164, dealing with electric fans of all types.

Induction Motors.—WRIGHT & WOOD, LTD., HALIFAX. List No. 24 gives prices and descriptions of a line of two and three phase induction motors.

Electro-Medical Apparatus.—SANITAS ELECTRICAL COMPANY, LTD., LONDON, W. Very complete catalogue, extending to upwards of 300 pages, dealing with every form of electro-medical apparatus as supplied by this company.

D.C. Motors.—UNION ELECTRIC COMPANY, LTD., LONDON, S.E. List No. 1012 gives dimensions, prices, and illustrations of a line of d.c. motors, and also of the "Fortiter" starters made by this company.

Machine Tools.—H. W. WARD & CO., BIRMINGHAM. This well-known firm of machine tool makers send catalogue M.G., which illustrates and describes a wide variety of modern tools and accessories.

Tantalum Lamps.—SIEMENS BROS. DYNAMO WORKS, LTD.—Below is the reproduction of an artistic show-card recently published by this firm and which explains itself.

Trade Notices, &c.

The Electrical Contractors' Association advise us that owing to the great strides they have made it has been necessary for them to take larger offices at 20, Bucklersbury, E.C. As from July 7th their offices will be No. 582 on the 4th floor of this building instead of, as heretofore, on the lower ground floor. The telegraphic address and telephone number will remain the same.

Arc Lamps, Ltd., have recently removed from Camden Town to their new factory at St. Albans. We are asked to notify that Frampton & Paine, 29, Old Queen Street, Westminster, will hold a stock of their carbons, globes, and other spare parts.

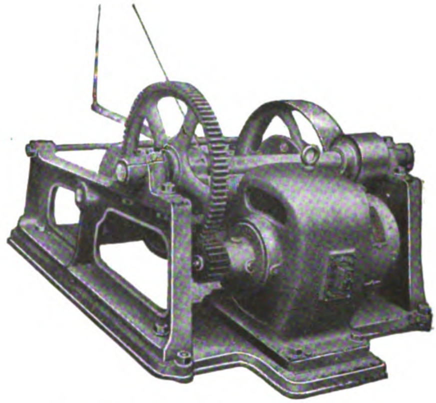
William McGeoch & Co., Ltd., have removed their London headquarters to 90, Charing Cross Road, where they will have greater office and display accommodation.

Oerlikon Turbo-Generators.—Mr. G. Wüthrich of the Maschinenfabrik Oerlikon advises us that his company has received a repeat order for two 6000kw. turbo-generators for the City of Stockholm. Another recent order for similar plant was placed by the Kensington & Notting Hill Electric Lighting Company, in this case the turbo-generators being 1600 to 2000kw., three-phase.

Electromotors, Ltd.

Description of Apparatus on their Stand at the Franco-British Exhibition.

This stand contains an example of a shunt-wound semi-enclosed-type motor of the above firm's latest manufacture, capable of developing 10h.p. at 1000r.p.m. It is complete with baseplate with belt-tightening gear, and it is typical of a range of sizes of these motors. There is also an electrically driven friction hoist designed to lift a load of 5cwt. at a speed of 150ft. per minute, consisting of an intermittently rated compound-wound motor gearing into a wheel on the second-motion shaft.



Electrically-driven Friction Hoist.

To lift the load the friction wheel on the barrel is brought into contact with the friction pinion on the second-motion shaft. When the lever is released the friction wheel falls back on to a brake, and the intermediate position represents lowering.

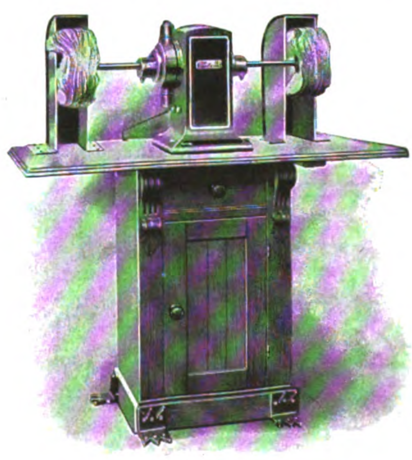
There is also an example of a three-throw ram pump, direct connected to its motor by means of gearing; and self-contained typical examples will also be found of worm and spur gear motors, the worm-gear sets having solid-steel worms provided with ball-thrust bearings, and running into machine-cut worm wheels with phosphor-bronze rims, the spur-gear sets having machine-cut teeth throughout, the pinion being of raw hide, and the second-motion shafts are carried in self-lubricating bearings.

A small centrifugal pump is also shown circulating water through a glass tank mounted on columns.

An acquisition to the stable will be noticed which we understand will clip a horse in thirty minutes. There will also be found one of a range of portable electric drills for use in shipyards, boiler shops, &c., the one shown being provided with a pot magnet drill pillar for attachment to flat iron surfaces without the use of bolts.

A 30in. ventilating fan is also shown, and

Standard Semi-enclosed Motor.



Electric Boot Polisher.

a few minutes spent at the photograph stand is an education in the application of motors to all kinds of trades.

Collective Exhibit, Kitchen Dept.

In the kitchen, Electromotors, Ltd., have three useful exhibits. The knife-cleaning machine, which is capable of cleaning upwards of 1000 knives per hour, is of a type designed to rather burnish the knives than grind them away. It consists of a small motor driving two discs through enclosed bevel gearing, the disc being covered with a special quality of tanned hide. There is also a silver polisher, and they also have a boot polisher which is mounted on a neat cabinet, and consisting of a specially designed motor, with the shaft extended at each end provided with suitable buffs for the above duty.

Electromotors, Ltd., have supplied the two 13kw. low-voltage motor generators, in the centre of the Collective Electrical exhibit, which are supplying power to the neighbouring apparatus.

General.

Electromotors, Ltd., have supplied quite a number of machines to various other firms who are exhibiting, and amongst which might be mentioned the *Daily Mail* Pavilion, where two motors are driving their printing machines; motors supplied to the Linotype Machinery Company, Ltd., which are now driving a portion of the printing machines in the special apparatus of the *Daily Mirror*. Motors were also supplied to: Messrs. H. J. West & Co., in the Canadian section, Messrs. Robert Legg, Ltd, John Holroyd & Co., Drysdale & Co., Follows & Bate, Southall & Smith, Harrild & Sons, John Hadden & Co., and several others.

The

Electrical Magazine.

VOL. X. No. 2. LONDON. AUGUST 15th, 1908.

The World's Electric Progress.

Electricity in Mining.

THERE is every excuse for setting apart a number of *The Electrical Magazine* exclusively for information regarding the use of electricity in mining. Remarkable progress is being made in this direction, and in all parts of the world wherever mining is to any appreciable extent engaged in will be found the greatest accomplishments of electrical power engineers. In coal-mining areas, where fuel is the one thing in plenty, but where it is also the marketable asset, there are electric power stations of the largest sizes and most economical designs; every ton of good coal used here means a tax upon the profits of the mine, and as opposed to its use there is at hand such an abundance of small, inferior coal—waste so far as market is concerned—that the most modern power-generating plants for consuming low-grade fuels are demanded. In those cases where furnace coke is a staple article, the waste heat of the coke-ovens is used to fire boilers, or the spare gas is collected, cleaned, and used direct in gas-engines.

In metalliferous and gem-mining districts it is a general rule that fuel is a scarcity, and when it does exist in the locality it is usually in the form of timber, peat, or other low-value bulky fuel necessitating for its use the provision of specially designed economical plants. Then, again, in those districts where fuel is not, there is frequently some large source of water-power within electrical distance of the mining field, and one finds that the most noteworthy hydro-electric power plants and high-tension electrical transmission schemes of the world have their origin in the power requirements of the mining industry. Where neither combustible fuel nor "white fuel," as the waterfall has been so aptly termed, exists, then it becomes entirely a question of importing the means of power generation, and whether it be coal or oil its value is correspondingly great. Thus from all points of view the mining industries of the world, dependent upon heavy power supplies, beset by inherent natural difficulties, and always in a keen competitive state, provide the finest examples of electrical power generation on a large and economical scale.

In considering the application of electric power in and about mines, the prominent phases are the extremely adverse surroundings under which all such plant has to work, the heavy powers required in small compass, and the widely-separated power centres. There is no need to reiterate here the peculiar advantages possessed by the electric motor and the electric system generally for service of this description. Indeed, it may be taken for granted that mining engineers are agreed as to the pre-eminence of the electric drive for pumps and haulages in-bye and on-bank and for practically every power service in mining, except, possibly, main-shaft winding, coal cutting, and rock drilling.

It would seem that practice in electric pumping and hauling has become very largely standardized; the leading makers of the combined sets have adopted well-defined lines to suit the more usual conditions and requirements and to comply with the definite Government rules established. Electric winding-gears are as yet a novelty in this country; that they are practically and commercially successful has been amply demonstrated abroad, particularly by our Continental neighbours, and it is only a matter of a short time, when the one or two now under construction in this country are set to work, for their use to be definitely established here. Electric coal cutters have for many years been known and used in this country; that they are not always considered satisfactory is due to the repeated failures of the early pioneer machines. The present-day machines, designed after experience, are quickly breaking down prejudice and ever coming into more general use. So far as coal or rock drills are concerned the electric system is at a disadvantage in that it does not very readily lend itself to the actuation of a reciprocating motor. Augur or rotating electric drills are in considerable use for the softer grades of rock and coal, but for hard materials the reciprocating bit is preferable and compressed air is more generally adopted. There are, however, one or two well-known forms of electric reciprocating drills which have also been adopted to some extent and are doing good work.

As we have seen, therefore, there is very much in the details of electrical mining practice that is practically standardized, and we have consequently devoted the major portion of this Special Number to articles by well-known engineers, experienced in electrical and mining practice, which set forth those general phases of the wide subject "Electricity in Mining" which are more of a controversial character than are purely technical descriptions of work done. In taking up this line we believe that the best purpose is served, since it is on broad lines that future great modifications of electrical practice in mining will be based, rather than on the perfection of mechanical details.

Public Electric Supply Development.

THE article by Dr. Herzfeld in this number is well worth the very close attention of colliery proprietors, landowners, and municipal authorities. The combination of coal-masters and municipalities for the securing of cheap and abundant electric power which has been brought about in Westphalia can only make for the success and profit of all the parties concerned. Power engineers know full well that the pit bank is the economical power-generating centre, and that to distribute high-tension current from the colliery to surrounding townships even over a very considerable radius would introduce such economies as to make the present ruling prices of municipally-generated current absurdly high. This country may be in favour of municipal electricity control, but that is no reason why every little township should have a central generating station to itself; it could still keep sufficient control over its electricity supply by entering into partnership with its municipal neighbours and the owners of the nearest collieries to secure an economical and ample current supply. It would be the best thing in the long run for the ratepayer of many of our towns to have the Council do away with the local electricity works, and join in with a co-operative system such as is described by Dr. Herzfeld.

The Manchester Electrical Exhibition.

THE work of organising the Electrical Exhibition which is to be held in Manchester during October proceeds apace. Already over two hundred firms have taken space, and these include not only those dealing in electrical specialities, but those connected with practically every branch of engineering to which electricity is applied. It would seem that the variety of exhibits and the success of the exhibition will surpass even the most sanguine expectations.

ELECTRICITY IN MINING.

THE ELECTRICAL DEVELOPMENT OF A LARGE MINING AREA.

DR. R. HERZFELD.

THE fact that the problem of electricity supply for industrial districts is just now engaging the attention of many people in Great Britain and in the Colonies, and also the undoubtable fact that so much capital has been lost in various electric power undertakings that it is almost beyond possibility to raise fresh capital for such purposes, encourages the author to put before readers some few facts and figures which bear on this question and may be of some use at the present juncture. They are taken from one of the most important Continental coal fields, the Rheinish Westphalian district, which extends from the Rhine to the centre of Westphalia, near Hamm, 100 miles long and 40 miles wide, which has during the last decade been visited by a great number of British mining engineers, and to the methods of which so much criticism, partly favourable, partly unfavourable, has been extended.

Whatever the opinion about the general working of the Westphalian mines may be, it seems that the conditions in that district from an electrical point of view are entirely satisfactory. Every colliery or other industrial concern which desires electrical energy for developing or running purposes, can obtain as much as it requires at a moderate rate without being forced to go to the financial and technical risk of putting down its own generating station. It is evident that such facilities influence materially every mining proposition and encourage the development of new areas to a great extent.

Of course, there exist in this country some very important supply systems, which allow the mine owner to draw upon them, like the citizen draws on the public water supply, but it must be admitted that such is not the condition in the majority of the mining districts. Even where the usefulness of electricity has been realised by a large number of industrial concerns suitably situated, it has not been possible to combine all the interests concerned to a commercial success and so to lay out the distributing mains that the electric current stands waiting at the consumer's door to be taken in. A large capital is required, and the encouragement is not great. There are wayleaves which have to be bought at considerable expense: there are small and incapable bodies in existence which have launched out in connection with the supply of electrical energy at a time when nobody could foresee what future develop-

ments would be, and whose endangered interests arouse the sympathy of the authorities as soon as a more comprehensive scheme puts in an appearance: there are vested interests of all kinds which ask for and receive a great deal of consideration and sometimes block the way by some prohibitive conditions ; and on top of this the decision of so many matters concerning the industrial needs of the country is in the hands of people of high social standing, but with little commercial training, who in spite of all the shouting of the press and large bodies of representatives of commercial interests still take up an attitude which is as hostile to the real interests of the industry as any protectionist may accuse a free-trader of being.

The Rheinish Westphalian coal field, the most important in Germany, is one of the principal districts which has encouraged the development of the electrical industry in its early stages. According with the experimental nature of the earlier installations, the course taken by the mine owners was to erect their own power station most suited to their individual requirements, and it was only after a certain standardisation of electrical mining plants had been attained that the problem of electric power distribution over the district could be tackled successfully. A great stimulus to this development was supplied by the Ilgner system of winding, which brought one of the most difficult plants in the series of power-consuming machinery almost to the uniform and easily handled level of a lighting load. This was realised by some far-seeing mining magnates at an early date ; they grasped the possibilities and went ahead on broad lines. They first acquired the control of the Essen generating station, which they soon developed from an ordinary municipal undertaking to an important factor in the industrial evolution of the neighbourhood. Powerful commercial interests were soon combined, and the foundation of the Rheinish Westphalian Electric Supply Company took place, the service starting in the spring of 1900. At that time the total capacity of the station was 3000kw., and it gives a proof of the quick growth of the undertaking when it is mentioned that its capacity is to-day over 21,000kw. divided into three stations, one of which, at Essen, supplies the mining area ; one, at Solingen, is right in the middle of the celebrated steel industry ; and the third one, near Cologne, links up various industries near the Capital of the Rhine, on the opposite bank of the river.

Soon afterwards the Eastern parts of the district also felt the necessity of a reliable source of electric power, and the municipality of Dortmund took advantage of the situation and extended their mains over a large area. This again stimulated the Rheinish Westphalian Company, and they also entered the eastern sphere in 1905 by laying out a large station at the Wiendahlsbank mine, near Kruckel, which was designed for a total capacity of 30,000kw. By this means they would have secured such a strong position in the whole of the district that, unless some immediate action was taken, the authorities would have found it very difficult not to grant them the right of also providing the middle part—the district of Bochum—and so securing practically the monopoly for the electric supply of the district. Therefore the Government encouraged the foundation of a new supply company called "Westphalia," mainly composed of a number of small rural districts, which undertook to serve the area round Bochum by means of a ring main fed from the surplus power of various large colliery concerns. Thus the development and the future of the new generating station at Kruckel received a serious check. The Rheinish Westphalian Company was effectively prevented from connecting its new mains with the older system around Essen. At the same time the municipality of Dortmund and other like corporations which felt the powerful position of the Rheinish Westphalian Supply Company tried to combine against it on the eastern border of the district.

The position in 1906 was, therefore, briefly as follows :—

The western part of the district—with the exception of some of the larger towns which, for tramway and lighting purposes, had their own generating stations—was served by the three stations of the Rheinish Westphalian Company, at Essen, Solingen, and Cologne.

The eastern part was served by the Dortmund Municipal Station.

The middle part—with the exception of large towns like Hagen and Bochum—was served by two systems—"Kruckel" and "Westphalia"—which were both at the beginning of their career and backed up by very powerful interests, partly outstepping each other's area and carrying on negotiations

with the remaining industrial and municipal concerns independently of each other.

There were men in each camp who saw how unreasonable this conflict was and who tried to combine the divergent interests, but this proved to be a very difficult commercial problem.

The various corporations who saw the common enemy in the Rheinish Westphalian Supply Company tried to combine against it, but could not agree upon the locality of the new generating station nor about the distribution of the shares. Time went on and the position of the public company grew stronger and stronger, and under this pressure at last an agreement was arrived at in the beginning of this year, which involves such new features for those interested in the public supply of electric power that a short description of it may not be out of place.

The principal data at that time were as follows :—

	No. of kw. Installed.	No. of kw. Connected.	Km. Cables.	Units Generated per year at the rate of	Capital Outlay.
Rheinish Westphalian Company, Western Section	17,400	27,000	882	29,000,000	£800,000
Westphalia Electricity Company	—	2,500	400	7,000,000	—
Rheinish Westphalian Company, Eastern Section (Kruckel) ..	8,200	5,500	350	5,000,000	£300,000
Municipality of Dortmund..............	12,000	14,400	537	8,000,000	£350,000

The deciding step in the negotiations was that the Rheinish Westphalian Electric Supply Company offered the sale of the newly-erected generating plant at Kruckel to the combine at cost price plus 15 per cent.; and this offer was finally accepted on the following basis :—

A limited liability company called the Westphalian Verbands Elektricitäetswerk was founded with a share capital of £165,000 and an authorised debenture capital of £330,000. The shareholders of the company are as follows .—

	£
Municipality of Dortmund ...	67,500
Westphalia Electric Supply Company	30,000
County and City of Hoerde...	22,500
Rheinish Westphalian Electric Supply Company	15,000
Harpener Coal Company	15,000
Gelsenkirchener Coal Company	15,000
	£165,000

All these interests are represented on the board.

The purchase price of the Kruckel station and mains is about £350,000; the remainder of the capital will be used for immediate extensions at the estimated value of £75,000 and as working capital. Simultaneously a complete agreement has been established between the various competitors which provides limits to the sphere of each of them. Every one of the shareholders is further bound to take a certain amount of current from the new company, viz., a minimum of one million units for every £15,000 shares per annum at a price of 6pfg. (say ¾d.) per unit.

From the latest reports it seems that the new company is rapidly approaching an annual output of 40,000,000 units in its own area, so that the load offered by the shareholders on the border lines of its own territory will not be required. Of course the contract price for electricity gives hardly any inducement to the latter to buy any large quantities, and the stipulation, which was only formed a year ago as a sort of guarantee for the success of the company, is of no little importance to-day, the only advantage being that the older concerns get the benefit of a certain stand-by. The total amount guaranteed, however, is a very small quantity as compared with the actual requirements of the industry of the district, which a conservative estimate puts down at the present day at 200,000,000 units per annum.

Although the list of shareholders of the new company, short as it is, is itself a very interesting document and shows at a glance how simply, nay elegantly, the apparent difficulty of a cut-throat competition has been solved, there is one notable omission in it: no contractor's name is included. And from the experience gained in this country in similar undertakings the promoters of the company can be heartily congratulated for this, as they are thus able and certainly will get their plant independently in the best markets, benefiting undisturbedly from the wide experience of their managers.

It is evident that an undertaking which is inaugurated with so much wisdom and with the co-operation of practically all the parties concerned carries with it a high prestige, and will in itself remove many doubts which mine-owners in other districts still hold as to the advisability of a connection with a public supply.

The conditions vary in every district, and one circumstance, the great quantity of water which the mines in Westphalia as a rule have to deal with, and which greatly contributes to the success of the electricity supply systems, does not command the same importance in any of the districts of the United Kingdom. But all the same it will be a matter of serious consideration whether a similar combination to the one described would not be possible and beneficial in this country. The history of the Westphalian Verbands Elektricitäetswerk certainly contains food for thought from an administrative, a legislative, and a commercial point of view.

CONSIDERATIONS ON THE DESIGN OF POWER STATIONS FOR MINES AND COLLIERIES.

GERALD HOOGHWINKEL, M.I.E.E., M.I.M.E.

The design of power stations for mines or collieries offers a far greater variety than the beaten track followed in the design of power stations for lighting and tramways—mines situated in far-away countries where skilled-labour difficulties in effecting repairs, scarcity of fuel, and inaccessible mountain roads offer so many rocks on which the designer of the power station is likely to strand. On the other hand both load factor and diversity factor are very much better, so that the producing costs can be kept fairly low, given the best design to meet each particular case.

General.

In the following notes the writer wishes to discuss some general arrangements and types of plant which will meet each case under certain conditions, as it has been his good fortune to have been called to design nearly every kind of equipment, including steam, gas, water power, and oil engine stations. The latter, viz., the Diesel engine, is coming rapidly to the front in cases where oil fuel of some kind is readily obtainable, and where little water is available and coal is dear. In stations of medium capacity, in mountainous districts, these engines will prove cheap and reliable electric power producers. The choice of plant is governed by so many variable conditions that it is impossible to be guided by general rules, and each case must be substantially judged on its own merits. It is evident, however, that the presence of a fairly constant source of water power with a sufficient fall at a reasonable distance (this distance may be taken as proportionate to the amount of power required up to say 100 miles for large power) should be utilised. It is however a mistake to suppose that water power is always cheaper. This depends largely upon the fall and the works required, as the interest and depreciation upon works and plant constitute 75 per cent. of the working costs. With steam coal at anything under twelve shillings a ton it will be found that only in the case of a fairly high fall, and consequently a moderate quantity of water and cheap works, water power will be more economical than steam or gas. In the few calculations published in connection with the Victoria Falls scheme the cost per kw. installed was

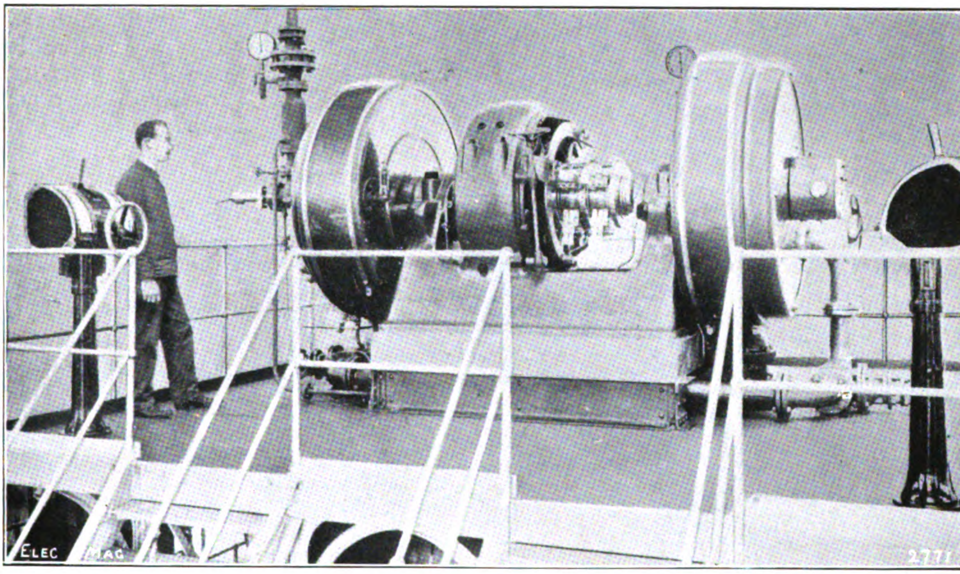


FIG. 1. 150KW. STEAM TURBINE PLANT AS FOR SMALL MINING INSTALLATION.

over £100 as against £12 for a steam station (on or near the site where the power is to be used). With coal at £1 per ton or over, as in most of the South American States and parts of Spain, gas plant begins to enter into serious competition with steam. It must not be forgotten, however, that the advances in steam plant have been quite on a par with those of gas engine and producer plant.

Steam.

Steam turbines, especially of the action or direct-flow type, have simplified the steam engine part of the station enormously, especially as regards buildings, foundations, repairs, &c.

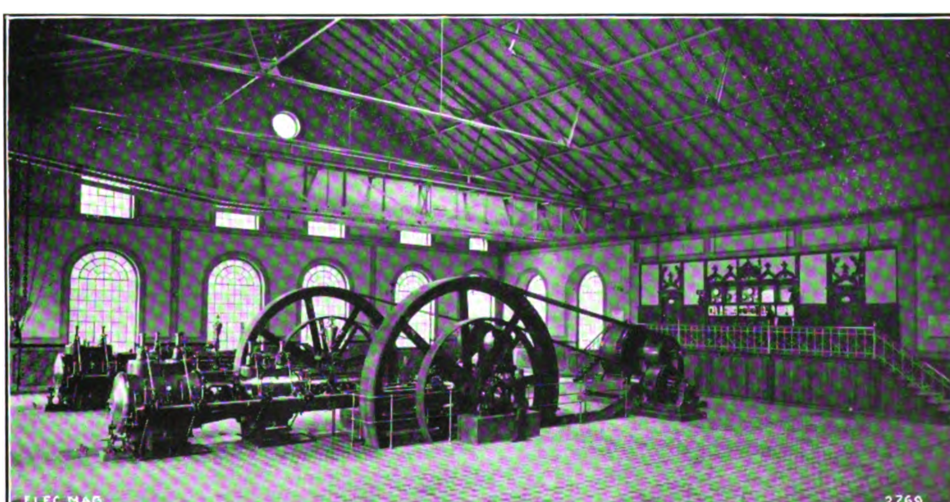


FIG. 2. GAS-ELECTRIC POWER PLANT AT THE SALT MINES, HERCYNIA.

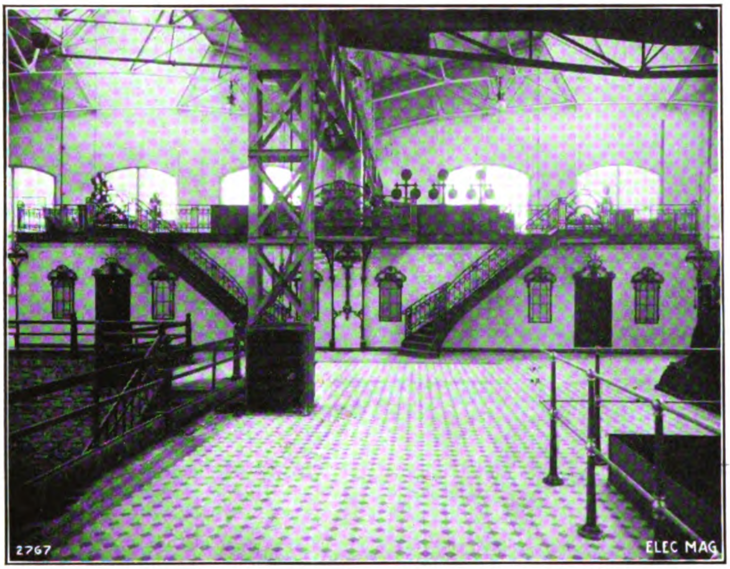


FIG. 3. TYPICAL LARGE GAS-ELECTRIC POWER STATION ON THE CONTINENT.

be put at from 1.5lb. to 1.75lb. of fuel according to the load factor for plant up to 1000h.p. For metal mines generally situated in places where coal is dear or unobtainable the question of efficiency becomes important enough to be considered against the established simplicity of modern steam plant. For collieries gas producers and gas engines as main power plant are out of the question at present because of the large power requirements and cheaper fuel. As auxiliaries, however, they have a distinct and useful application.

But also, and this seems to be the secret of economical supply, the boiler house is beginning to attract the attention of engineers, which has so long been lacking. So long as a Lancashire boiler (30ft. by 8ft. 6in.) can be made to give from 4000lb. to 12,000lb. of steam with but slightly different fuel, so long will it be ridiculous to quarrel about a slight difference in efficiency between a turbine or vertical or horizontal compound engine. It can, however, be said for the turbine that for large units, as will be required more and more for the wholesale electrical equipment of mines and collieries (electric winding, &c.), the turbine is bound to win, as it is possible to concentrate power of say 3000h.p. to 5000 h.p. in such a small space and in such simple apparatus as no reciprocating engine can show.

Gas Plant.

A modern and economical boiler house, however, which must include mechanical stokers, feed heater, economiser, CO_2 recorder, superheaters, &c , is becoming a fairly complicated affair, and it is in simplicity of that part that the gas producer plant scores. The producer plant, especially of the down draught suction type, is much simpler, easier to handle, and requires less repairs and maintenance than an up-to-date boiler plant with its auxiliary machinery. The efficiency of the combined plant is much higher and may

Gas producers or coke ovens should be used to deal with the unsaleable slack and other coal of little value depending on the demand for coke in the district. They should also be used to supply the necessary gas for heating the oven flues, the gases of which may be used in gas engines.

The engine part of the gas plant, however, has certain limitations, and although they are constantly being perfected, the gas engine is not yet as reliable as the steam engine, and repairs are decidedly more costly and frequent. The troubles which are being experienced, and which may count for little in engineering districts, become of the highest importance in out-lying districts and far-off mining camps, where extensive repairs are not possible and everything has to be done by the staff. These troubles are generally associated with the ignition (back-firing and pre-ignition) and water jackets. As a result of this, spare parts and plant are required on a much more liberal scale than with steam plant, and this partly compensates the cheapness of the producer plant. The limited overload capacity of the gas engines tends to the same results. Curiously enough, however, these troubles and repairs in some recent large gas-power plants have originated in the producers.

As far as other running costs are concerned, apart from fuel and maintenance,

Fig. 4. Four 200 h.p. Gas-electric Generators in the Power House of a German Mine.

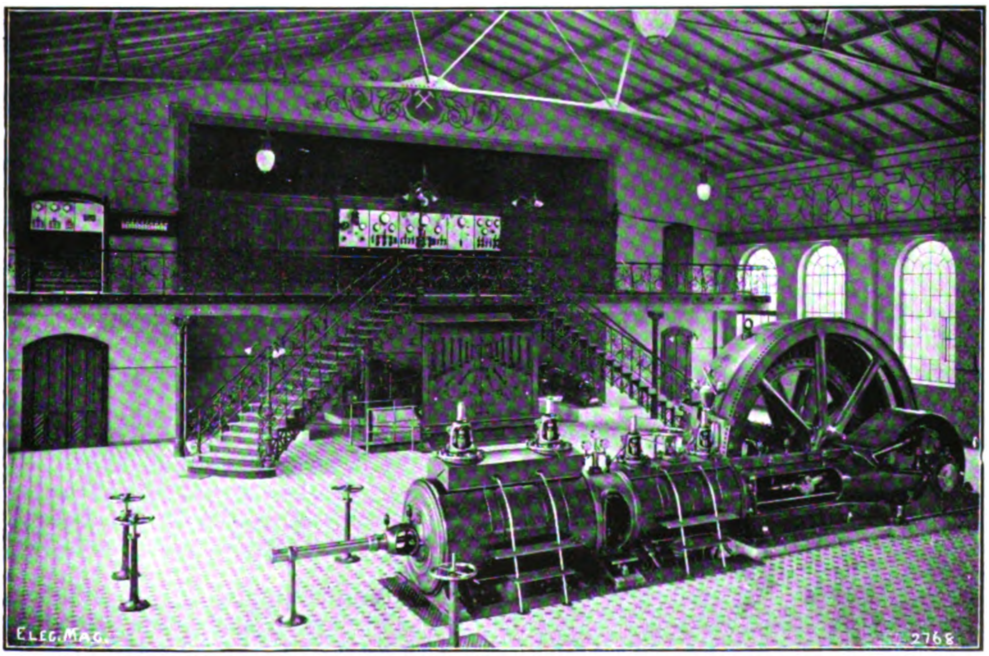


Fig. 5. Horizontal Steam-electric Plant at the Salsdetfurt Salt Mines.

there is little to choose between the two plants. The producers require very little attention and care, and it is easier to make a good gas of uniform grade, and work the producers at their highest efficiency, than to get the same effect from boilers. The producers require less difficult and frequent cleaning, can be got ready much more quickly, and present less dangers if carelessly handled. The amount of water required is between that of a non-condensing engine and a condensing engine, being about 200lb. per unit for plant of about 1000h.p. Wages may therefore be less on account of the handling of the producers. The amount of lubricating oil is usually more than in the case of steam engines, especially turbines. The most important point therefore to guide the engineer in his decision, whether and which kind of gas producers he shall adopt, is the fuel available. If coal has to be imported, or brought some distance, it will pay to use the best hard coal or anthracite, and in this case the producing plant is simpler, as no tar-extracting or by-product plant is required. For fairly small power plants this is the best plan, but for larger stations in places where local or cheaper coal is available, it will be found that steam plant is better in the end. However, soft coal can be used in down-draught producers even without tar extracters or by-product plant, but careful and frequent inspection and cleaning of the engine, valves, &c., is an absolute necessity. Coke is a very successful fuel for producers, but need scarcely be considered as far as mine or colliery plants are concerned.

Coke-oven gas engines and blast-furnace gas engines are much more reliable, and the large gas engines will mostly be found in connection with these sources of power. In large coking collieries where a type of oven is installed, adapted to the particular class of coal produced, having regard especially to their yield of gas, the coke oven gas power station by means of gas engines will soon be acknowledged the only correct solution, although at present this is still considered to be an open question.

Another point which has to be considered is the load factor of the power plant. In large collieries the writer has obtained 50 per cent. and over if the main winding is done by means of electricity, and a fair amount of pumping is required. In metal mines where stamp mills and other continuously running plants form the greater part of the load this may even be exceeded, and 72 per cent. has been found in one particular gold mine in South Africa. With this load factor the following figures were obtained during a test on a 700-1000h.p. gas power station using soft coal (14,000b.t.u.) with down-draught producers:—1.37lb. of coal per unit, 1.47 cubic feet of gas per unit (including 3 per cent. water gas). The plant consisted of two 9ft. producers and two 600h.p. Crossley engines (32in. by 36in. cylinders).

In a steam power station of the same size the fuel consumption would have been 3lb. to 4lb. of fuel per unit, so that the fuel consumption may be taken at half. With coal at over 15s. per ton, gas power plant is decidedly more economical for stations of moderate capacity (up to 1000h.p.) and the advantages increase as that capacity *decreases*.

The scope of this article does not enter into details as to the selection among various types of producers and engines. Simplicity in construction and handling, freedom from repairs and breakdowns, form practically the only considerations. The writer favours producers of the Morgan and Duff types and four-cycle double-acting engines of the multi-cylinder type. Moderate speeds can be obtained by vertical engines of this type with direct-coupled generators. This construction also permits running with some of the cylinders only, which is a decided advantage in cases of small breakdowns, cleaning, &c. The many small cylinders can be much stronger and of more compact design than the few larger ones, thereby reducing one of the great difficulties in gas engine design.

Oil Engine Plant.

There remain to be considered two other power generators which in far-off countries and out-of-the-way situations are coming more and more to the front—the Diesel engine and the water turbine. The first from a theoretical point of view is the most perfect power producer yet constructed. The absence of all ignition troubles, the simplicity of construction, and the facility with which nearly all classes of oil fuel may be used, give a great advantage for all pioneer work.

The price is at present still a drawback, but although the Diesel engine will never be cheap to construct, standardisation of sizes will soon tell its own tale. Of course a

cheap and reliable supply of oil fuel of some kind is a first requirement, but, given this supply, the Diesel engine has many advantages for power plants of medium size, such as are to be found at metal mines in mountainous districts. Their freedom from breakdowns, small housing, little attention and cleaning required, will secure for them a very large field of application. The latter point is of special importance, and it reduces the skilled labour bill, which in the mines under consideration is always the most important point. The absence of repairs and trouble is of course due to the absence of explosion, of a carburetter, back firing, &c., all of which often cause trouble in other oil engines or gas engines.

With oil at about 50s. per ton the production costs have been as low as c.25d. per unit, including all capital charges. Of course this kind of plant is restricted to those countries where oil is cheap, such as Roumania, the United States of America, the East Indies, Burma, the Straits Settlements, Mexico, the West Indies, and Venezuela. Recently some 500h.p. Diesel engines have been shipped to foreign mines, and in the countries mentioned above this engine will soon form the bulk of the mining power plants. Most of these countries may be said to be mining countries, and produce little or no coal. Especially the tin mines in the Malay States are beginning to realise the advantages of a cheap and reliable oil supply from Sumatra, and are now abandoning the apparently cheap but wasteful wood and husk fuel. One of the latest installations with Diesel engines as prime movers has just been ordered by the Bahang Corporation.

If properly erected and adjusted they require very little cleaning and repairs. On the other hand, the various parts are rather heavy, and as transport is generally the great stumblingblock in most of the countries enumerated above, this disadvantage must not be neglected.

Water Power Stations.

The principal condition which governs the use of a natural head of water in the neighbourhood of a mine are—

(*a*) Constant supply, or adequate storing capacity for the dry season.
(*b*) Head.
(*c*) Distance from the mine.
(*d*) Length of open canal, pipe line, and general cost of works.
(*e*) The cost and supply of other fuel.

In those countries where coal and other fuels are scarce, as a rule water power is to be found in abundance, and the choice of the driving power is an easy one. If, however, good coal or crude oil is to be had at prices up to 30s. for the former and 50s. to 60s. for the latter the cost of the water power installation and transmission lines must be carefully considered, as the capital charges form by far the greatest part of the generating costs. In most cases, however, it will be quite easy to come to a conclusion on this point, especially in such countries, where coal is dear, as Norway, Sweden, Switzerland, Peru, Brazil, New Zealand, the Central Provinces of India, Spain, Italy, Canada, &c.

Details of Construction.

It may be useful to deal with the details of the power station design after the driving power has been agreed upon.

Steam Stations.

The details of power stations designed for mines in foreign countries depend of course largely upon—

(*a*) The climate.
(*b*) The life of the mine.
(*c*) Cost of the various materials which enter into the construction.
(*d*) Means of transport.
(*e*) Import duty.

It is desirable to use local materials as much as possible, on account of the points mentioned sub. ***a.***, ***d.*** and ***e.***, and it will be found that (local) stone buildings with a light steel roof will answer in most cases. In some parts bricks are available, but cement is nearly always expensive, and its use should be avoided as much as possible except for heavy foundations and chimneys. Ordinary or reinforced concrete buildings will therefore not often be found, and brick buildings are also the exception. For temporary work, or at sites where stone and lime are expensive, galvanised corrugated iron buildings are often used, while for roof work this material is very convenient.

In tropical countries this material should be avoided for walls, and may be used for roof work only when doubled and if an air space is left between. Even stone walls

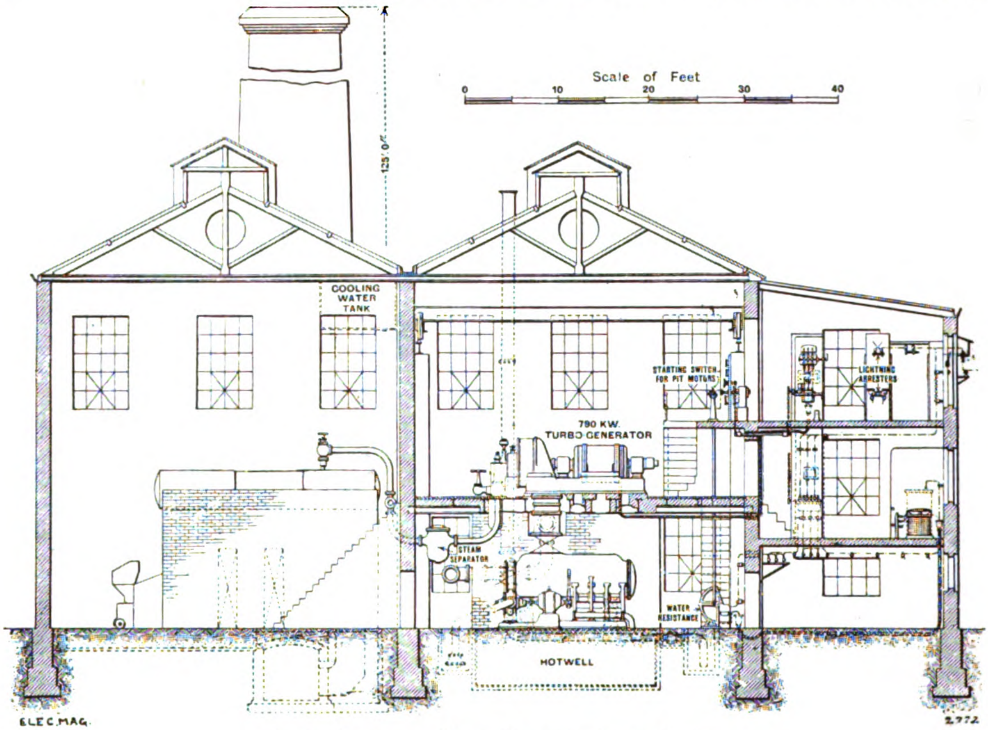


FIG. 6. SECTION OF TURBO-ELECTRIC POWER HOUSE.

between engine-room and boiler-house should be constructed with an air space between them, and the outer walls should not be less than 18in. thick. Plenty of room should be allowed in the power-house, and excellent ventilation must be the rule, so as to avoid the effects of climatic influences, and to ensure the good health of the staff. Cemented floors are mostly met, but a brick floor is often cheaper and just as neat. Plenty of light (both daylight and artificial) is a necessity, as it is in power stations at home.

The arrangement of the building of course depends on the type of plant installed and labour conditions. Modern steam turbine plant is generally installed in such a way that the condensing plant (surface condensers) are on the ground level with the turbines mounted on girders on concrete pillars. Even if barometric or jet condensers are used this arrangement is to be preferred, so as to leave room for condenser pumps and to shorten the exhaust pipes, &c.

With vertical or horizontal engines, which require heavier foundations, this arrangement is too expensive and the engines with their condensers and pumps should be on the floor-level.

In most mines a good deal of pumping is done, and in that case barometric condensers or modified syphon condensers should be used, arranged outside the building. Surface condensers should be avoided as much as possible, as they are a continual source of repairs and require more attention than any other part of the plant.

The condenser and feed pumps should be half electrically and half steam driven, so as to ensure freedom from breakdowns.

The type of the electrical equipment depends of course on the nature of the plant which has to be driven, but as a rule three-phase systems with a pressure of 2200 volts to 4400 volts and a frequency of 25 cycles will be found most suitable, depending on the distance the power will have to be transported. With water-power stations, however, which may be situated some distance from the mine, these pressures are often exceeded. Where only surface plant, such as electric locomotives, winding and hauling gears, are required continuous-current systems have certain advantages, but these conditions do not often occur. In that case, however, full advantage should be taken of the use of accumulators.

The size of the units depends of course on

the load conditions and load factor. The power required at a melt mine of average size is not of the same order as that of a colliery, and the best arrangement is always to design the power plant in such a way that one unit can take care of the entire requirements of the mine. If turbines and to a certain extent other steam plants are installed the overload capacity should be large so as to cope with the variations in the power demand. In mines where the power demands during the night shifts are much smaller than during the day shift a separate small unit should be installed; but if the night-load is about one-half or upwards that of the day load it will generally pay to run the larger units. This refers to units up to 1000kw. If the day load is much larger, three units, of which two are on load during the day, and one spare will be found more economical, but the multiplication of the units should be avoided as much as possible.

The same refers to the boiler plant; water-tube boilers of the Marine or Stirling type are finding more favour even for mines in far-away countries, on account of easier transport, better economy, absence of economiser plant, and additional safety. The quality of the water must, however, be carefully recorded, and an efficient treatment plant erected. Money spent on water-treatment plant with water-tube boilers is money well spent. Cooling towers form a useful addition where water is scarce, but must be designed in accordance with climatic conditions. They require little repairs, and ground space is, as a rule, no consideration. Superheaters should be added with a certain amount of caution. Too much superheat is a nuisance, especially with turbine plant and vertical engines, and a separate superheater may be found to be better practice, all on the score of repairs and maintenance of the boilers.

The question of mechanical stokers depends entirely on the fuel available and the efficiency of the boiler-house staff. With fairly good and efficient labour and Welsh or equivalent coal, mechanical stokers can be dispensed with, but these conditions are seldom to be met with. Otherwise they will be found to be a necessity, especially where bad native coal must be used.

Short chimneys with induced draught are preferable in small installations of the pioneer type, but if chimneys are being erected reinforced concrete will in most cases be cheaper in maintenance and even in first cost than steel. Brick chimneys are much dearer in most countries where mining is

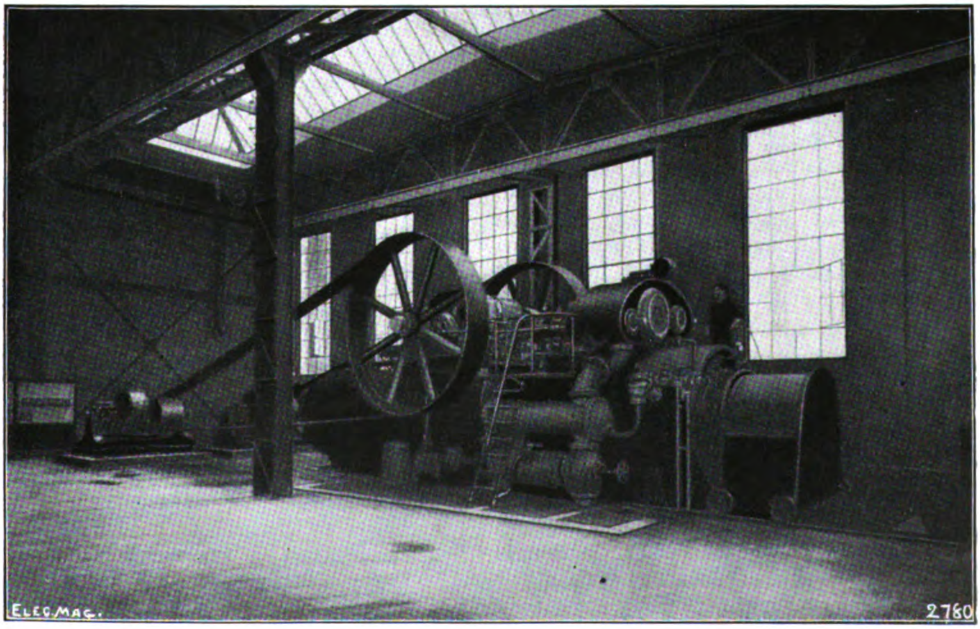


FIG. 7. 300H.P. WOLFF LOCOMOBILE-ELECTRIC PLANT AT CHILIAN NITRATE WORKS.

carried on, both on account of labour and materials.

For small power installations for, say, up to 200h.p. or 300h.p. the best steam installation is the modern compound steam locomobile. The writer has had most excellent results with this type of plant, even in countries where transport is difficult. The Lanz and Wolff locomobiles may be cited as a model of this type of power plant. Buildings, labour, and repairs are reduced to a minimum, and transport on wheels is nearly always possible.

The question of the weights of the various parts is often the first consideration, and in such cases the various parts must be specially designed. In one of the installations with which the writer has been connected, viz., the water-power station at the Redjang Lebong gold mine in Sumatra, no part was to be heavier than 1200lb. They had to be carried by eight coolies each 100 miles from the coast on bad roads, and the rotors and stators of the 125kw. dynamos had to be wound on the spot.

A hand crane both in the engine and boiler house is well worth the money it costs, especially if so arranged as to serve the repair-shops as well.

The switch-gear should always be installed in a separate building. This reduces the cost of the main building by lessening the number of large spans, and also to a certain extent danger from fire; a lean-to building costing little to construct is sufficient. Care should be taken to install only the simplest type of switch-gear, and the writer favours the more old-fashioned air-break type of gear for the moderate pressures mentioned before. This does not apply to colliery plant at home, where oil switches of more modern construction are always installed, but it has been the writer's experience that, given plenty of room, the simpler type of switch-gear gives less trouble and is just as safe if enclosed in expanded metal compartments. The view (Fig. 9) of a typical high-tension installation at a colliery abroad illustrates the writer's point of simplicity and easy repairs by the local staff.

Gas and Oil-Power Stations.

The arrangement of the power station is much simpler in these cases, as the producer plant, storage tanks, and cleaning plant may be erected in the open or covered with a cheap corrugated roof, while only the engines proper and switch-gear are installed in the power-station. The same remarks as to building and arrangements apply here, but the question of the size and output of the units requires careful consideration. The maximum output of an internal combustion engine means the output which can be maintained continuously with the most economical mixture. In other words, the gas-engine, and in a lesser degree the oil-engine, requires to be from 50 to 70 per cent. larger for the same maximum effort as the corresponding steam-engine. The units should be kept down to much smaller sizes, preferably of the multiple cylinder vertical type, so as to ensure continuous running should one of the cylinders give out. Sizes up to 500h.p. to 750h.p. are at present a maximum for this type of engine. The storage capacity for oil-engine (Diesel) plant should be ample for, say, a three to four months' supply. If cooling water is not available in sufficient quantities, cooling towers will be necessary. Direct engine-driven plant is to be preferred, but the cost may be decreased a good deal if rope drive is adopted.

Water Power.

The construction of power station foundations and penstocks are now nearly always concrete and reinforced concrete structures. The head and rate of flow will determine the type of turbine to be used, but in most cases sufficient head is available to use a Pelton wheel type turbine.

1. For the low heads up to 40ft. American type of turbines with horizontal or vertical shaft in open flume nearly always with draught tube.

2. For heads over 40ft. up to 300ft. radial inward flow action turbine with horizontal shaft and concentric or spiral cast iron case with draught tube.

3. For heads over 300ft. impulse turbines (Pelton wheel type) or radial outward flow, full or partial action turbines, with horizontal shaft.

The horizontal shaft arrangement is nearly always preferable, on account of ease of access for adjustment or repairs and easy connection to dynamos. Only with very low heads are vertical arrangements necessary. Also in cases of a great rise of the tailwaters in times of flood, as their being submerged does not interfere with their operation. The vertical arrangement requires less build-

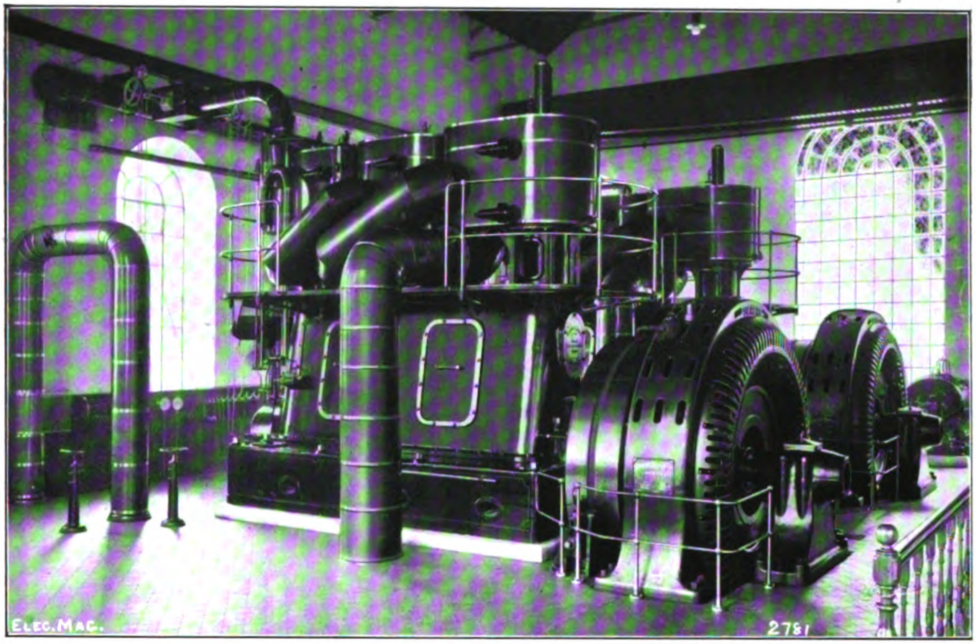


FIG. 8. 500KW. ALTERNATE-CURRENT HIGH-SPEED STEAM SETS. CAMBRIAN COLLIERIES.

ing work, as the turbine may be set at any elevation. There are also less friction losses (on account of water thrust) and cast iron cases and draught tubes may be dispensed with, the foundations forming the case.

The dynamos should always be direct driven, even if, with very low heads, a vertical slow-speed turbine is used.

The turbine frames, which should be of cast iron, should be supported on a reinforced concrete construction where the tailrace is below the turbine.

They should be rigidly bolted to the dynamo frames, and in their shape no sudden changes of direction should be allowed. For turbines working under a great head and exposed to severe end thrusts, thrust pistons should be used, with a separate water supply where the water is gritty.

The gate opening and closing arrangements connected with the governors will not be separately described, as they belong to the details of the turbine.

The low-head turbines should be set above the tail-water if the head is sufficient to give enough depth of water above the turbine. If not, a single or multiple vertical turbine becomes a necessity. In that case, however, a separate tail-race should be provided for each turbine with one common gate, but with arrangements to put in stop-logs or loose gates in each tail-race for repairs. They should be inside the power-house.

For single or multiple horizontal turbines an open turbine chamber of reinforced concrete forming a direct branch of the head-race is the best arrangement. Open turbine chambers are always to be preferred, on account of reduced friction, ease of access, and easy speed regulation.

The same remarks apply to turbines for medium heads, except that the use of vertical turbines can nearly always be avoided. Double turbines may be arranged in one common case requiring less floor space.

In mining districts high heads will be the rule, and horizontal impulse turbines may be installed in nearly all cases, care being taken to set the turbines above the tail-water at flood tide. Draught tubes should be used wherever possible up to heads of 1000ft. on account of:

(a) Increased head.
(b) Decreased friction.
(c) Decreased windage.

For greater heads the diameter of the turbine (at 1000ft., 6ft.) increases too much, and renders the construction of an air-tight case difficult. In the construction of head- and tail-races, deep and narrow races should always be preferred, especially in localities

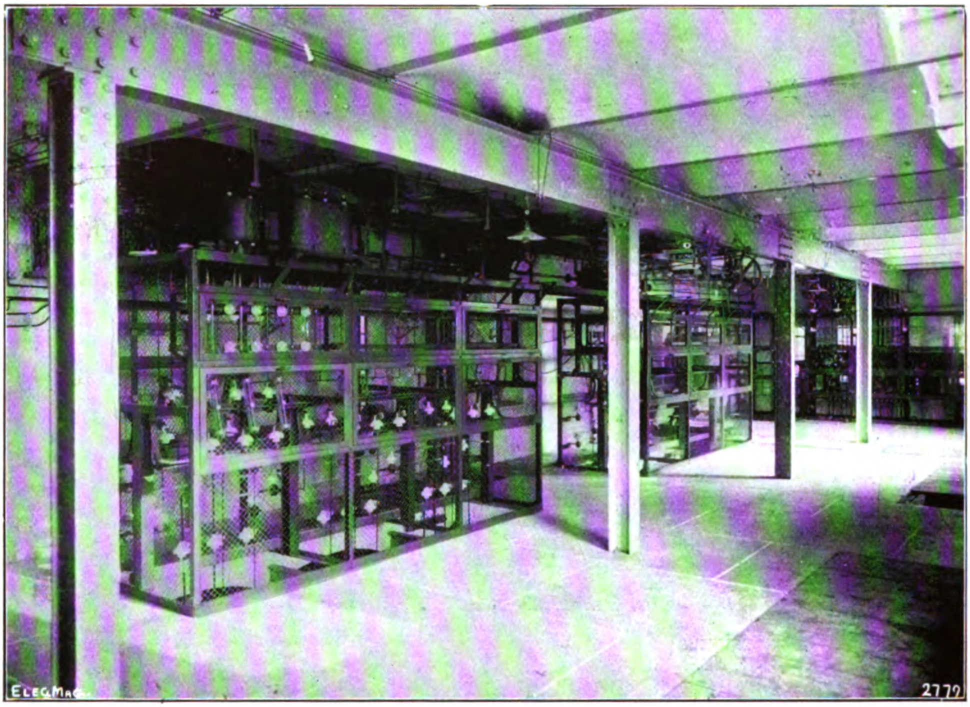


FIG. 9. 10,000-VOLT MAIN SWITCHBOARD AT A GOLD MINE POWER HOUSE.

where ice troubles may be expected. Bends should have a long radius, and the speed of the water should not exceed 3ft. per second. Sand-settlers and sluice-gates are placed at the power-house end of the head-race, the latter to discharge ice and rubbish from the head-race. The tail-race under the turbines should be of such a shape as to deflect the water in the proper direction.

Water-racks, both coarse and fine, head-gates for shutting off the water from the pen-stock or open turbine chamber, complete the arrangements. They should be made of steel and moved by means of hand and power. Balance or bypass ports are mostly added for large gates. Cylindrical head-gates are now coming into use, and, in the writer's opinion, are preferable from all points of view—such as low cost, always below water, perfect fit, and small power required to move them.

As stated before, concrete and reinforced concrete is now the essential material for foundations, races, and other constructional work—even for penstocks and pipe-lines.

General Remarks.

Another point which has to be mentioned is the plant for which the electric power is required. A modern installation at a metal mine includes the main winding, pumps, haulage underground and on the surface, compressors or electric drills, stamps, crushers, and auxiliary plant. The load factor on stamps, crushers, pumps, compressors, and endless rope haulages is of course high, and even the main, tail haulage, and winding plant can be compensated so as to give a fairly steady load. The load factor in the power station at a metal mine is therefore fairly high, sometimes over 75 per cent., taken over a shift, against 50 per cent. at a colliery. In some cases, if the other power requirements are heavy in comparison with electric winding, the equalising plant may be dispensed with, but the load factor in that case will be lowered. Whether these two points will balance is a question for careful calculation, but the simplifying of the electric main winding plant will do much to facilitate its introduction in all metal mines. The question of first costs does not enter so largely into these considerations as at a colliery, owing to the much smaller loads to be raised mostly from lesser depths. Whether electric winding is to be included in the mine equipment is a point which will also influence the ultimate choice of the size of the units.

COAL CUTTING BY MACHINERY.

A. S. E. ACKERMANN, B.Sc. (Engineering), A.M.I.C.E.

THE difficulties of coal-getting in the United Kingdom are much greater than in the United States. This should cause us to win a larger percentage of our coal by machinery for at least two reasons: (*a*) because, while the cost of the machines may be taken to be about the same in the two countries, the pit-mouth value of coal in this country is about one and a quarter times that in America, and consequently the relative cost of the machines is less; (*b*) because the more arduous work becomes, the more it should be performed by machines instead of animal labour. The second reason may not be thought of much consequence by the commercial man until it is pointed out to him that arduous work also means high wages and possibly a relatively large number of accidents. It is satisfactory that the ratio of the pit-mouth value per ton of coal in the United Kingdom to that in the United States has decreased, for while in the year 1900 the U.K. value was double that of the U.S.A., during the four years ending 1906 it was only about one and a quarter times as much. These figures include the value of the anthracite coal. If that be excluded, then the American coal shows a greater advantage in the matter of cheapness. Another very important reason for the use of coal-cutting machines is that it cheapens the cost of coal-getting. If it did not, then obviously machines would not continue to be used to the extent which they are; still less would the rate at which they are being further adopted be so great. This rate of increase in the number of machines in use is clearly shown by the steep slope of Curve Fig. 11. Hence it is obvious that the machines should be used to a still greater extent, for by that means the pit-mouth value of coal would be reduced. The nation with the cheapest coal has an enormous advantage, for coal is the life-blood of engineering, and engineering is the backbone of modern civilisation. If the reader should have any doubt about it let him for a moment think where the world would be without railways, steamships, wool and cotton mills, brick and tile making and woodworking machinery,

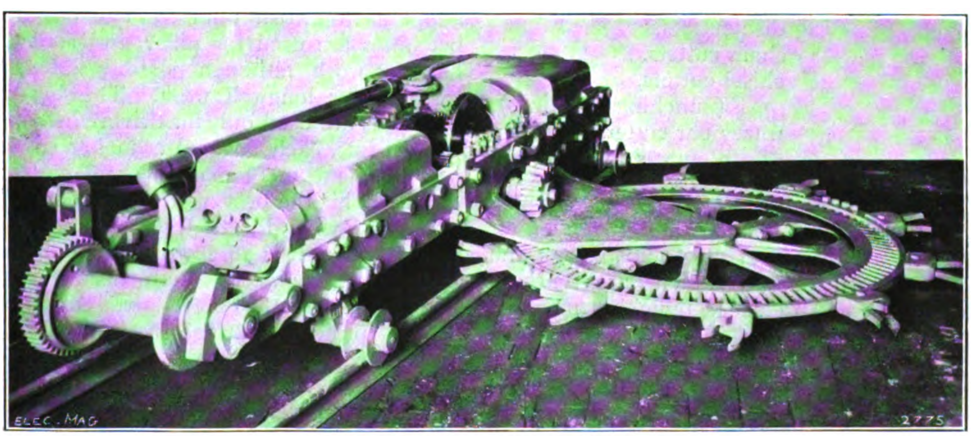


FIG. 1. DIAMOND DISC ELECTRIC COAL CUTTER.

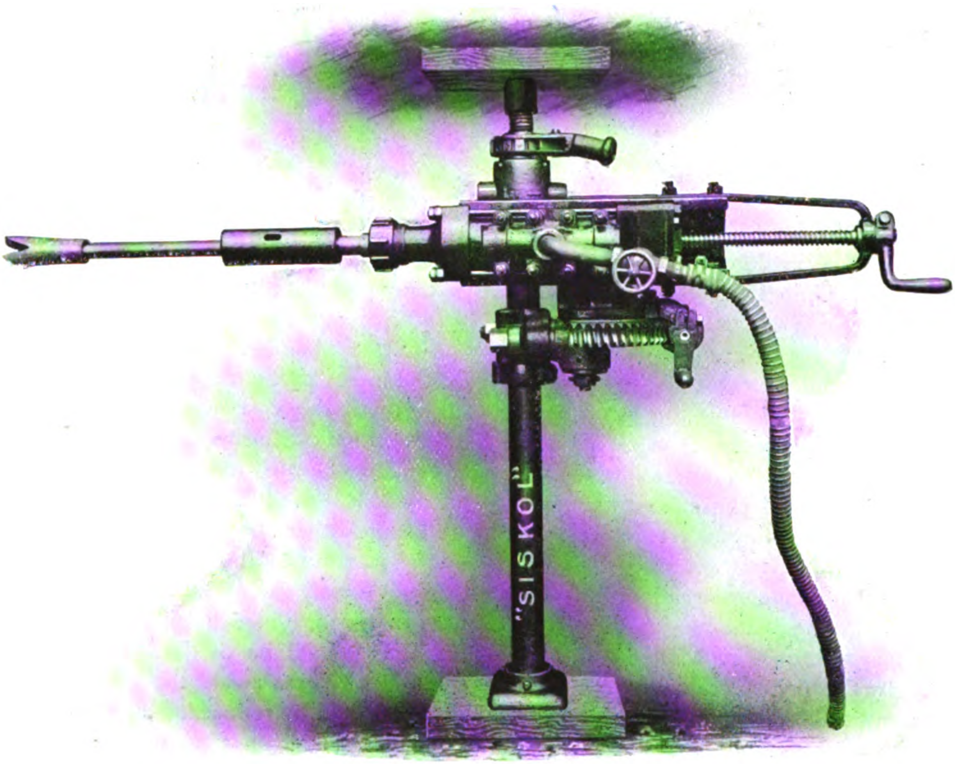


FIG. 2. SISKOL COMPRESSED AIR PERCUSSIVE MACHINE.

flour-milling and other machinery connected with the preparation of food, printing machines, and the telegraph and telephone.

Before briefly describing a few of the coal-cutting machines in more general use, it will be well to classify them thus :—

Machines having disc cutters.
,, ,, chain cutters.
,, ,, chisel cutters. (punching machines).
,, ,, rotary bar cutters
,, ,, crown cutters (heading machines).

The whole of these may be driven either by compressed air or electricity, except the punching machines, which are entirely pneumatic. An electric punching machine has been made, but it was not a success. The electric machines are either for direct or three-phase current. The disc, chain, and rotary bar machines may be arranged for longwall or for pillar and stall working, but the disc and rotary bar types are practically always longwall machines. The chain machines are usually used for pillar and stall working in America, this being the general system of working over there, while the chain machines in use in this country are nearly, if not all of the longwall type, as that is the general system of coal-getting adopted in British mines. The punching machines are used for pillar and stall and heading work, although possibly some may be used for longwall work. The heading machines are used only for driving headings.

As a rule, each coal-cutter maker specialises in one form of machine, and naturally considers his the best on the market. This is the case with all classes of machinery, and it is fortunate it is so, for one of the uses of unattached engineers is to decide which machine really is the best for given conditions.

The principal British makers of coal-cutting machines are :—

Anderson, Boyes & Co., Ltd.*
Clarke, Steavenson & Co., Ltd.

*For description of Anderson, Boyes & Co.'s Machines see p. 111.]

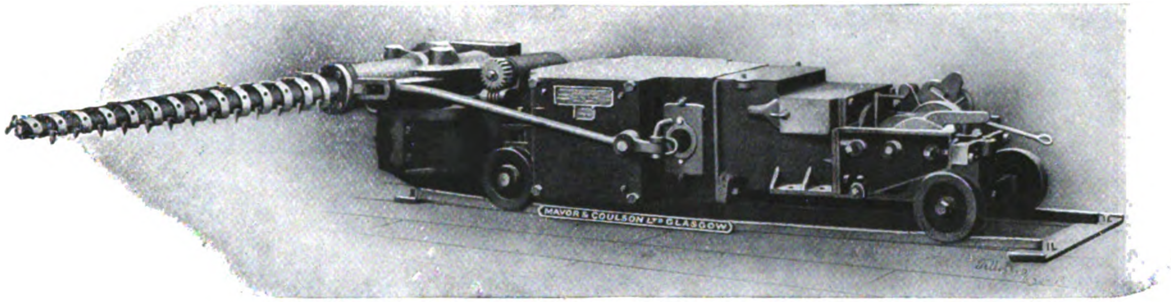


FIG. 3. MAVOR & COULSON ROTARY BAR CUTTER MACHINE.

- Cowlishaw, Walker & Co., Ltd.
- The Diamond Coal Cutter Company.
- John Gillott & Sons.
- The Hardy Patent Pick Company, Ltd.
- Austin Hopkinson.
- Hunter & Jack.
- The International Channelling Machines, Ltd.
- Mavor & Coulson, Ltd.

The principal American makers are:—

- The Belleville Pump and Skein Works.
- The Brown Manufacturing Company.
- The Goodman Manufacturing Company.
- Herzler & Henninger.
- The Ingersoll-Sergeant Drill Company.
- The Jeffrey Manufacturing Company.
- The Morgan-Gardner Electric Company.
- The Sullivan Manufacturing Company.
- The G. D. Whitcomb Company.

Clarke, Steavenson & Co., Ltd., were one of the first firms in this country to adopt electric driving for coal cutters. Their machine is of the longwall type with a disc cutter. The early patterns had spur and bevel gearing, but the latest design has worm gearing. The smallest size is only 18in. high, and the maximum depth of under-cutting is 5ft. 4in. The machine runs on skids, which are becoming more usual than wheels.

Cowlishaw, Walker & Co., Ltd., are one of the makers of Hurd's patent rotary bar-cutter longwall machines. They are electrically driven and have bevel gearing. The cutter-bar can be arranged for under-cutting or over-cutting, and it has a slow reciprocating (as well as a rapid rotational) motion for the purpose of keeping the bar free. The over-all dimensions of the smallest size of three are:—6ft. 6in. long, 2ft. 6in. wide, and 1ft. 1in. high; depth of undercut, 3ft. 6in.; b.h.p., 12; total weight, 1 ton.

The cutter-bar, by means of a worm-gear, can be swung round in a horizontal plane, and by this means the machine can "cut in" preparatory to making a longwall cut. Disc machines have to have a place cut in by hand for them to start from.

The Diamond coal cutters are among the

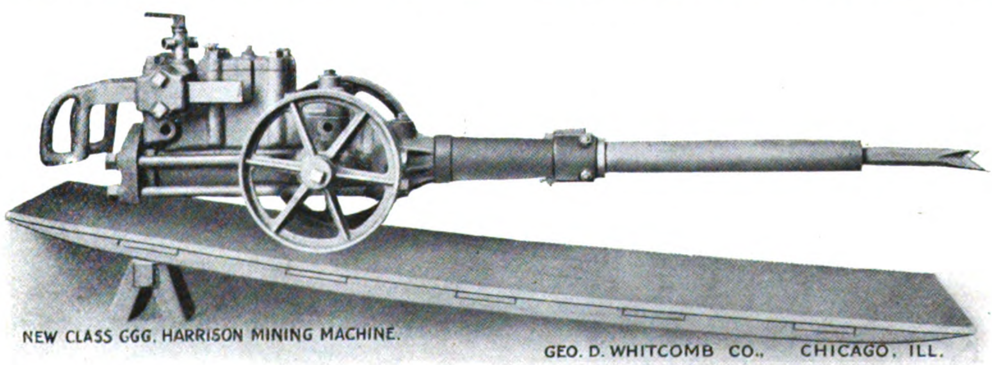


FIG. 4. HARRISON COMPRESSED AIR PERCUSSIVE MACHINE

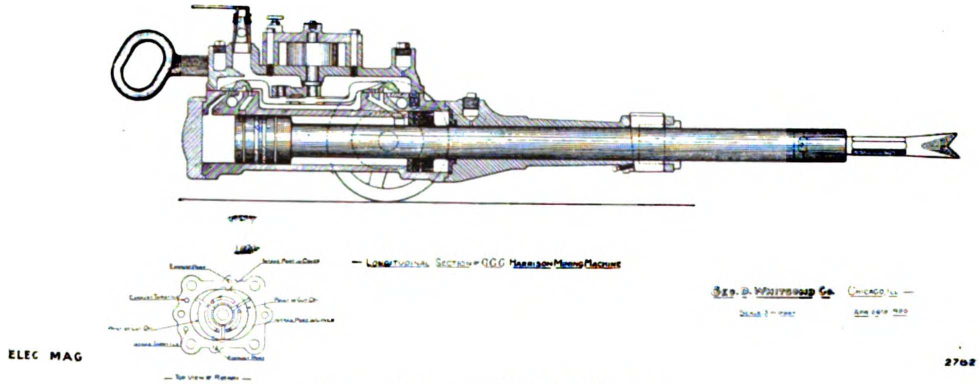


FIG. 5. SECTION OF HARRISON MACHINE.

best known in this country. Originally the company made only pneumatic, disc-cutter, longwall machines, but now they make also chain-cutter and percussive machines, the disc and chain cutters being driven by compressed air, or direct or three-phase electric current. The disc machines are arranged for either under or over cutting, and they cut to a maximum depth of 7ft.

The illustration Fig. 1 shows a disc cutter driven by two 10b.h.p. gas-tight electric motors. This machine undercuts to a depth of 4ft. 3in., while its height is 1ft. $10\frac{1}{2}$in.

John Gillott & Son confine themselves to the disc type of machine driven by compressed air or electricity.

The Hardy Patent Pick Company, Ltd., make a pneumatic percussive machine similar in principle to the "Siskol" machine which is illustrated in Fig. 2.

Mr. Austin Hopkinson was, the author believes, the first in this country to adopt the chain cutter, which is so very popular in America. This maker argues that the chain cutter is certain to be the survivor for nearly all purposes, and in consequence builds nothing but chain machines. It is certain that the chain type of coal cutter is more than holding its own in the United States, as will be shown hereafter when some leading statistics are dealt with. Mr. Hopkinson makes heading machines which are also suitable for pillar and stall work. The overall dimensions of the heading machine (or breast machine as it is called in America) are :—

Length, 6ft. 2in. ; width, 3ft. ;
Height, 2ft. 1in. ; weight, 18cwt. ;
Undercut, 3ft. wide by 4ft. under.

At present these are made for compressed-air driving only.

The longwall machines are made for compressed air or for electricity, and the jibs can be slewed through an angle of 180deg., thus enabling the machine to cut its way in before beginning a longwall cut. The overall dimensions of the electrically-driven machine are :—

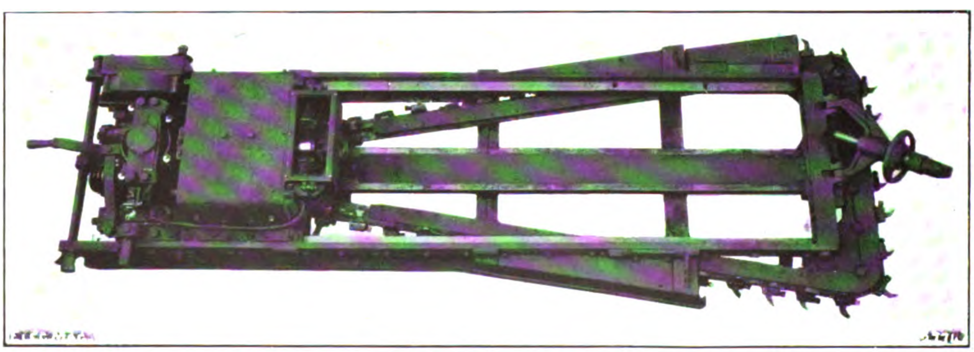


FIG. 6. JEFFREY ELECTRIC CHAIN MACHINE.

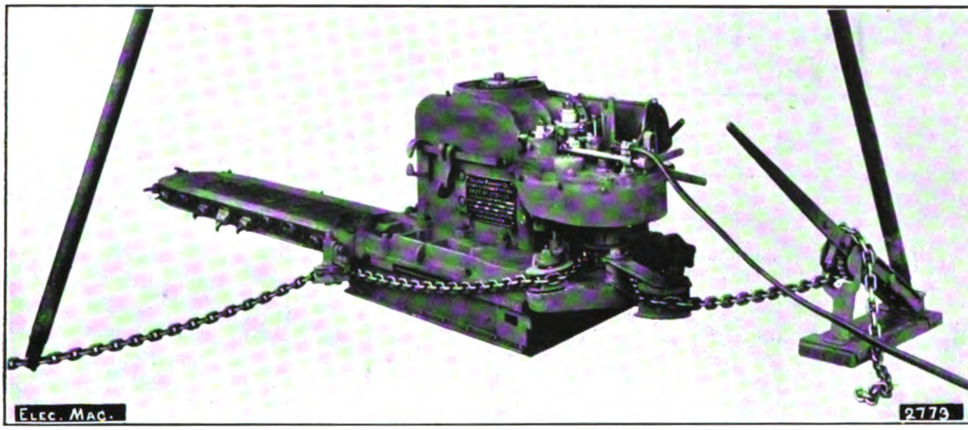


FIG. 7. SULLIVAN ELECTRIC CHAIN MACHINE.

Length, 6ft. 6in.
Width, 2ft.
Height, 1ft. 10in.
Weight, 25cwt.
Undercut. 5ft. 6in.

And of the pneumatic machine :—

Length, 7ft. 6in.
Width, 2ft. 3in.
Height, 1ft. 7in.
Weight, 26cwt.
Undercut, 5ft. 6in.

Hunter & Jack make electrically - driven disc machines. The motors are of 35b.h.p., the height 1ft. 8in., and the weight 35cwt.

The International Channelling Machines, Ltd., have changed the name of their firm and of their machines so often that readers may not recognise an old friend. The trade mark has been successively "Eisenbeis,' "Champion Eisenbeis," "Champion," and now it is "Siskol."

This firm has specialised in machines of the pneumatic percussive type, but which differ considerably from the American style of percussive machines. The latter are mounted on

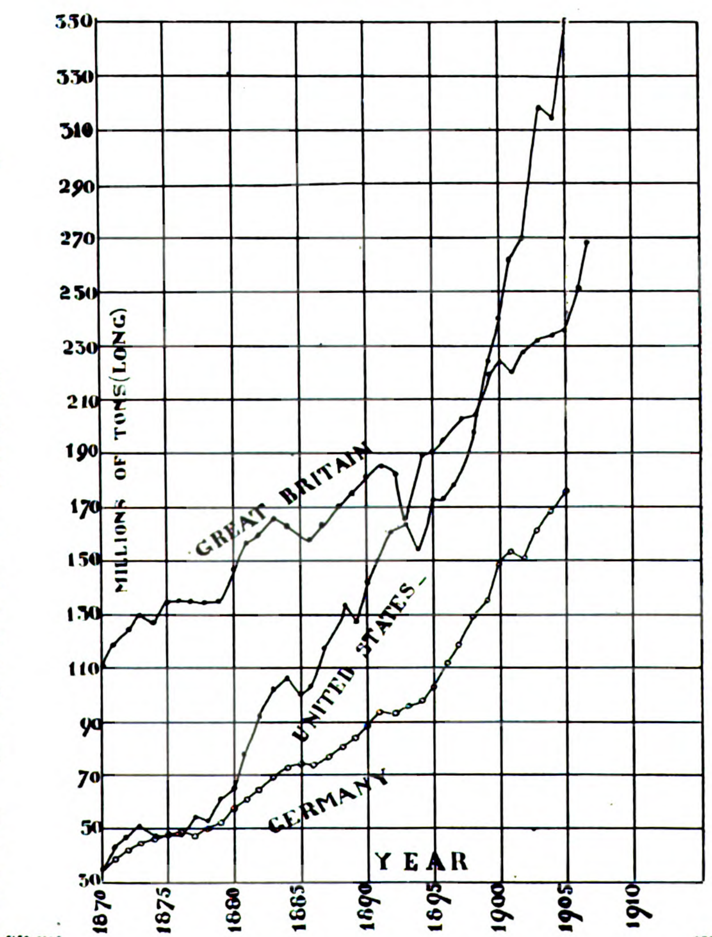


FIG. 8. TOTAL ANNUAL OUTPUT OF COAL IN GREAT BRITAIN, UNITED STATES, AND GERMANY.

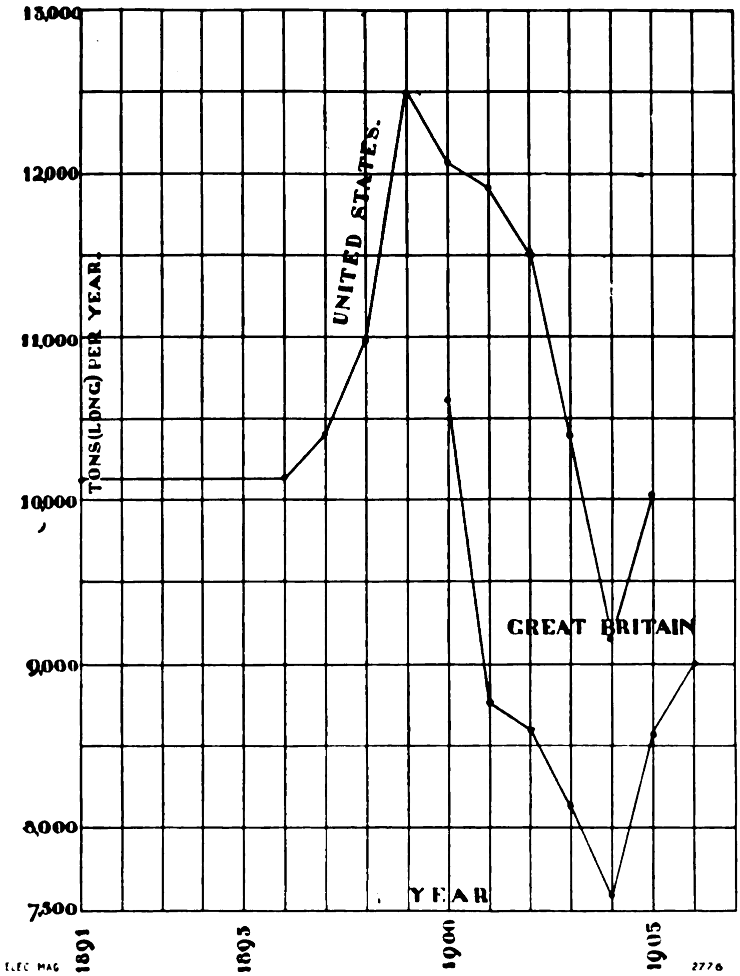


FIG. 9. COAL CUT PER MACHINE PER ANNUM.

incidentally, they publish the best catalogue and other literature of all firms making British coal-cutting machinery.

The machines are made for compressed air, and for direct or three-phase electric current, and are also arranged for running on wheels or skids as required. The overall dimensions of the four-cylinder pneumatic type on skids are :—

Length, 11ft. 9in.
Height, 2ft. 1in.
Width, 3ft. 11in.
Weight, 59cwt.
Undercut, 6ft.

The rotary bar cutter may be not only slewed through a horizontal angle of 180deg., but may be tilted in a vertical plane 20deg. above or below the horizontal.

The illustration Fig. 3 shows a rotary bar cutter machine.

Space will not permit of much being said about American

two small wheels, somewhat like an old-fashioned cannon, as shown in the illustrations of the Harrison machine, Figs. 4 and 5. The "Siskol" machine, Fig. 2, is mounted on a steel column which is jacked up between the roof and the floor. The weight of the column is 160lb., and of the complete machine 400lb. The machine can be fixed in any position on the column, and consequently can be used for over or under-cutting. The worm and segment arrangement is such that the machine can be used also for shearing, or drilling holes. For its operation the machine requires about 20 cubic feet of air per minute at a pressure of 80lb. per square inch.

Mavor & Coulson, Ltd., have adopted the Hurd patent rotary bar machine, and,

coal-cutting machines ; consequently they must be dealt with in groups.

Pneumatic percussive machines are made by the Belleville Pump and Skein Works, Herzler & Henninger, the Ingersoll-Sergeant Drill Company, the Sullivan Manufacturing Company, and the G. D. Whitcomb Company. The latter firm make the Harrison machine (illustrated in Figs. 4 and 5), which is typical of this group. The overall dimensions of this machine are:

Length, 6ft. 9in. ; width, 2ft. 3in. ;
Height, 1ft. 9in. ; weight, 6¼cwt.

This type of machine is very popular in the U.S.A., as will be seen by the statistical curves. In fact, this machine and the chain breast type are practically the only two in

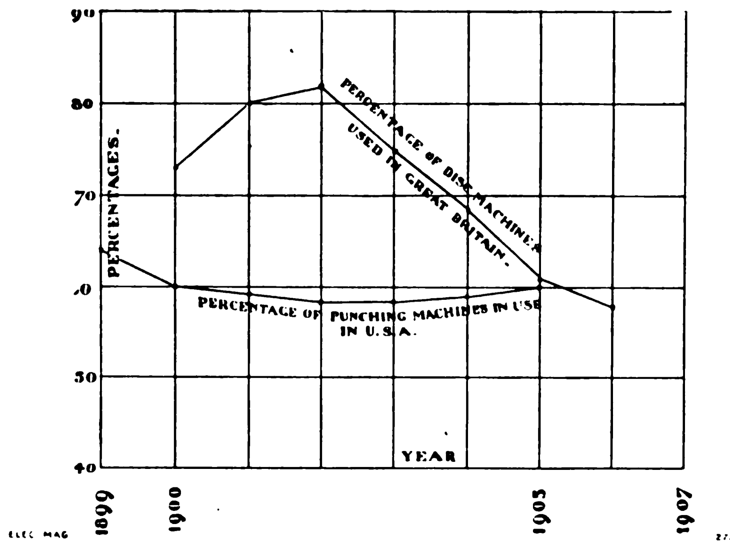


FIG. 10. PROPORTION OF TYPES OF MACHINES IN USE.

use. Chain breast machines, driven either by compressed air or direct or three-phase electric current, are made by the Brown Manufacturing Company, the Goodman Manufacturing Company, the Jeffrey Manufacturing Company, the Morgan-Gardner Electric Company, and the Sullivan Manufacturing Company.

An illustration of a Jeffrey d.c. electric chain breast machine is given in Fig. 6 as typical of this class.

The Jeffrey Company also make longwall disc machines. Longwall chain-cutter machines are made by the Goodman Manufacturing Company, the Morgan-Gardner Electric Company, and the Sullivan Manufacturing Company. An illustration of the latter is shown in Fig. 7, which shows clearly the ordinary chain by which the machine hauls itself along and keeps itself in the coal.

Statistics.

These are given in the form of curves, as they are more readily interpreted in that form. The curves have been plotted from the official returns of each country.

Curve Fig. 8 shows for comparison the total annual output of the United Kingdom and of the United States. It will be seen that in 1898 the outputs were equal. Since then America has gone rapidly ahead, but from 1905 to 1907 the British rate of increase was also very rapid.

Curve Fig. 9 gives the quantity of coal cut per machine per annum, taking all types of machines together. The quantity varies greatly, but since 1898 the average amount for America

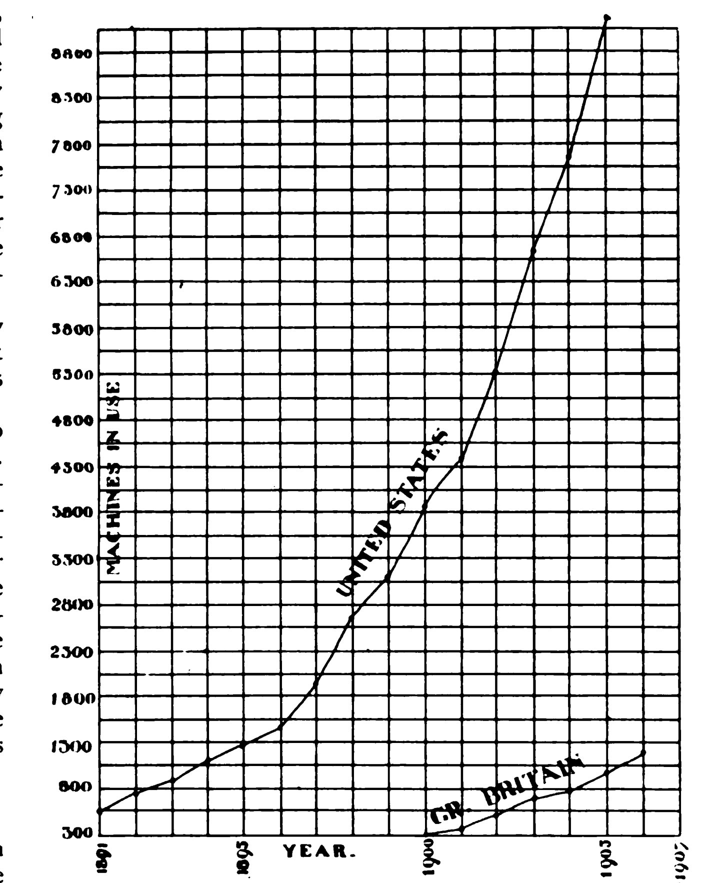


FIG. 11. TOTAL NUMBER OF MACHINES IN USE.

is about 11,000 tons per machine per annum, while in Great Britain it is about 8600 tons per machine per annum. The lesser quantity is no doubt largely due to the more difficult conditions holding in this country. It is very remarkable how these two curves follow one another, especially as no reason can be seen for any similarity between them.

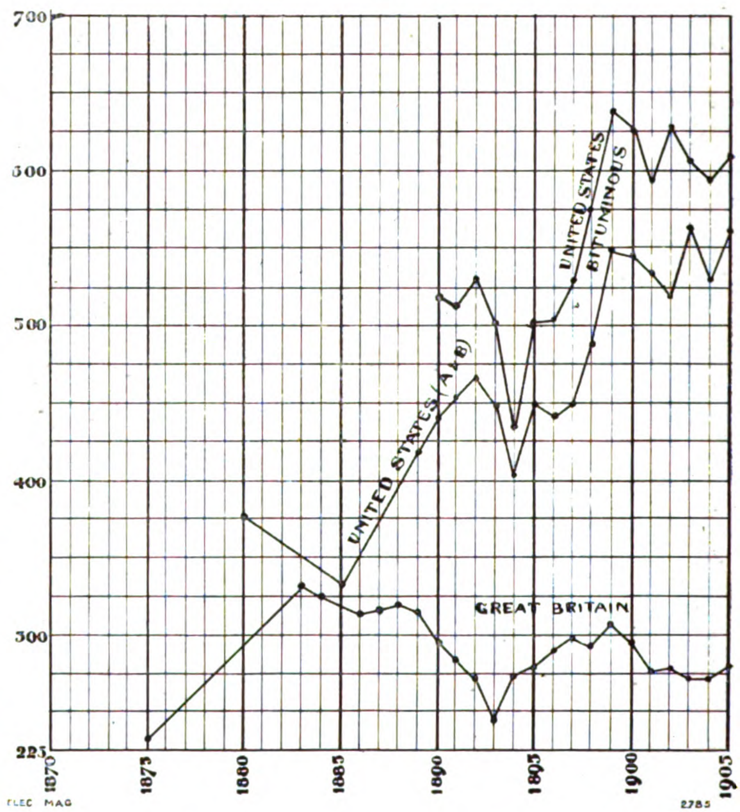


Fig. 12. Coal Cut per Person Employed.

Curve Fig. 10 is remarkable for two things: One the constancy of the proportion (60 per cent.) of percussive machines in use in America in spite of the rapid rate at which machines are being adopted in the U.S.A. as shown by Curve Fig. 11. The other remarkable feature shown by Curve Fig. 10 is the fact that the disc machine is not holding its ground in this country, though it is still the favourite machine, as about 60 per cent. of the whole are disc machines. The percussive machine is the cause of the fall in favour of the disc type, as the following table shows:—

Year.	No. of percussive machines.	Total No. of machines.	Per cent. of percussive machines.
1901	11	345	3.2
1902	29	485	6.0
1903	77	643	12.0
1904	122	755	16.2
1905	188	946	19.9
1906	254	1136	22.4

Curve Fig. 11 is striking because of the manifold difference between the total number of machines used in the two countries. In 1905 this country had 946 machines in use, while the United States had 9184, or nearly *ten times the number*, though in the same year the total quantity of coal raised by America was not quite $1\frac{1}{2}$ times the quantity raised by Great Britain. It is, however, somewhat comforting to notice that the slopes of the curves for the first five years after the adoption of machines in each country are almost the same, which means that the *rate* at which they were adopted in the initial years was nearly the same, though America started with 550 machines to our 311.

Curve Fig. 13 is perhaps the most striking of all, because of the enormous discrepancy between the total quantities cut by machinery in the two countries and the percentage these totals form of the total coal got in each case. In Great Britain, in 1905, the coal mined by machinery was 3.46 per cent. of the total won, while in the U.S.A. it was 26.3 per cent., or over $7\frac{1}{2}$ times the percentage. America produces a much larger percentage of anthracite coal than we do, and it is too hard to be cut by machine. If we leave out the anthracite, then America cuts 33.2 per cent. of her bituminous coal by machines

Curve Fig. 12 is also striking and brings out two things in particular :—

(a) That since 1903 the American miner has won double the amount of coal the British miner has, even when taking anthracite into account.

(b) That the anthracite is much more difficult to get, for if it is left out (and of course also the men employed in working it), then the amount of bituminous coal got per person employed in America is about 625 tons per annum.

Curve Fig. 13 shows a great change in the rate at which the percentage of machine-mined coal is increasing in the United States. The corresponding rate with regard to Great Britain also shows a *slight* increase, but the position of the British curves is not very pleasing.

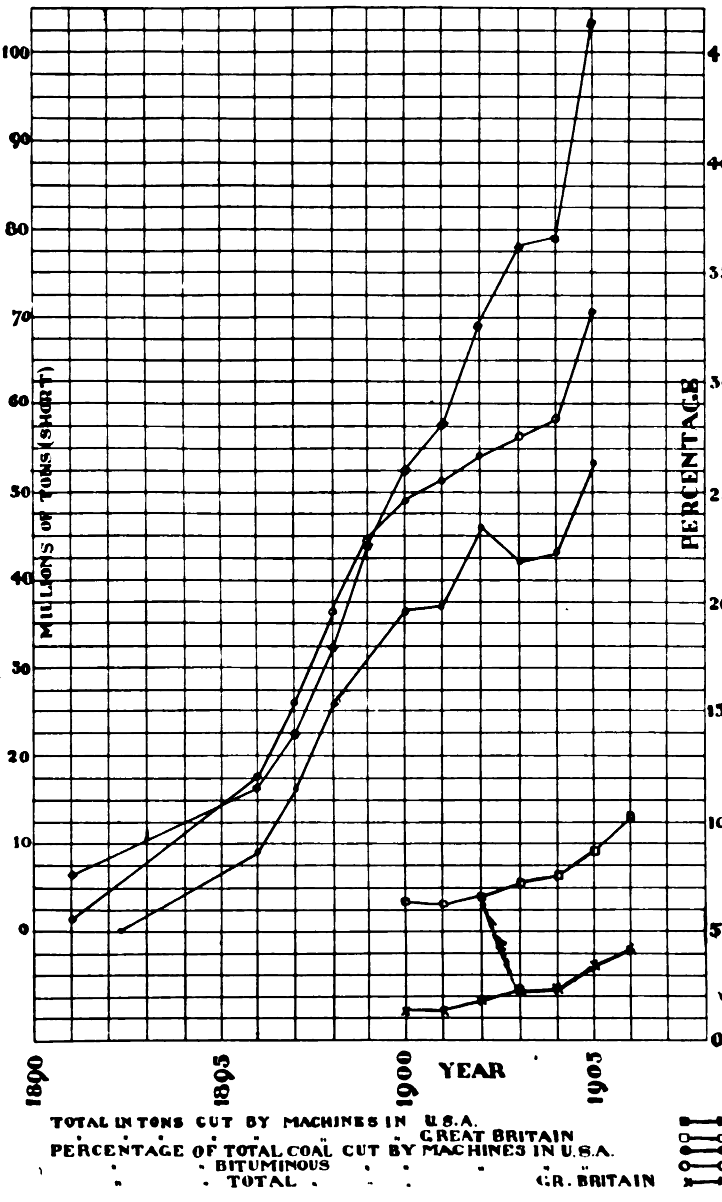


Fig. 13.

Influence of the Use of Machines on Accidental Deaths in Coal Mines.

Tables 1 to 5 have been prepared to show the effect of the use of machines in the United States. They each give corresponding particulars for each of ten States for the five years 1900-2 and 1904-5. Unfortunately the data for 1903 are not available. The ten States were chosen so as to include the most important coal-producing ones, and also those cutting large percentages of coal by machines and some of those cutting very small percentages by machines.

In dealing with accidents two figures are usually given, viz. the deaths per thousand persons employed and the deaths per million tons of coal raised. In the writer's opinion the latter is by far the more important one. We may take it that the world demands a certain amount of coal per annum, and does not in the least care how many men are employed in the getting of it. Therefore

the system which mines the coal with the least total loss of life is the best. This is not the same thing as a low death-rate per thousand employed, for to take an example in 1900 (Table I) the deaths per thousand employed, viz., 2.85 in Pennsylvania, were practically identical in the anthracite and in the bituminous mines, but the deaths per million tons raised were 8.03 in the anthracite mines, while they were only 3.72 in the bituminous mines. Hence we will take the deaths per million tons raised as the figure by which to judge the safety of the system of mining.

In Ohio during the three years 1900-2 the percentage of coal cut by machines was

Table I.

COAL-MINING ACCIDENTS IN THE UNITED STATES OF AMERICA IN 1900.

States (arranged in order of Col. 3)	Total output in long tons.	Percentage of bituminous mined by machines.	Total number of machines in use.	Total number of fatal accidents.§	Accidental deaths per 1000 employed.	Tons of coal raised per fatal accident.	Accidental deaths per million tons raised.
Ohio	16,950,000	46.53	341	68	2.46	249,300	4.15
Kentucky	4,760,000	43.91	239	17	1.76	280,000	3.57
Pennsylvania :							
Anthracite	51,221,353	—	—	411	2.85	124,000	8.03
Bituminous	71,360,000	33.65	1786	265	2.86	268,700	3.72
Indiana	5,800,000	27.36	254	18	1.55	322,000	3.10
Illinois	23,000,000	19.73	430	94	2.41	244,800	4.09
West Virginia	20,220,000	15.09	327	141	4.83	156,600	6.98
Arkansas	1,320,000	14.82	20	22‖	2.60‖	58,700‖	16.65‖
Colorado	4,680,000	14.42	90	29	3.89	161,200	6.20
Indian Territory	1,716,000	12.46	58	40	8.83	42,850	23.38
New Mexico	1,160,000	8.62	21	15	7.36	77,300	12.93
All the States	240,789,309	27.87‡	3907	1381*	3.08†	174,300	5.74
All England	225,181,000	1.48	311	1050	1.38	214,400	4.67

* Including 200 killed in one accident in Utah, May, 1900.
† Average for all the States for the 10 years 1891-1900, 2.73.
‡ 19.6 per cent. considering the total coal (anthracite and bituminous) mined.
§ Taken from an article by F. L. Hoffmann in the "Engineering and Mining Journal" of August 10th, 1901.
‖ There is some doubt about these figures.

Table II.

COAL-MINING ACCIDENTS IN THE UNITED STATES OF AMERICA IN 1901.

States (arranged in order of Col. 3).	Total output in long tons.	Percentage of bituminous mined by machines.	Total number of machines in use.	Total number of fatal accidents.	Accidental deaths per 1000 employed.	Tons of coal raised per fatal accident.	Accidental deaths per million tons raised.
Ohio	18,679,720	47.26	376	72	2.24	259,440	3.86
Kentucky	4,883,916	41.21	237	21	2.03	232,567	4.30
Pennsylvania :							
Anthracite	60,278,274	—	—	513	3.53	117,500	8.52
Bituminous	73,487,451	35.95	2,058	301	2.96	244,000	4.10
Indiana	6,177,343	26.77	256	..*	..	..	..
West Virginia	24,403,171	21.12	464	99	2.36	246,400	4.06
Illinois	21,489,664	20.01	403	134	4.34	160,300	6.24
Colorado	2,162,304	7.31	47	49	7.32	44,150	22.60
New Mexico	1,621,000	5.62	20	18	5.73	90,100	11.10
Indian Territory	5,090,000	5.60	62	55	6.21	92,600	10.80
Arkansas	970,130	0.24	6	9	3.63	107,700	9.28
All the States	261,874,836	25.68‡	4341	1467	3.04	178,400	5.61
All England	219,047,000	1.39	345	1131	1.44	193,700	5.17

* Not reported. † Fiscal year ending June 30th, 1901.
‡ 19.74 per cent. considering the total coal (anthracite and bituminous) mined.

46.53, 47.26 and 51.42 respectively, and the corresponding deaths per million tons raised were 4.15, 3.86 and 3.86, as compared with 4.67, 5.17 and 4.64 respectively in England. In the Pennsylvania bituminous mines in the same three years (in 1901 Pennsylvania produced 51 per cent. of the total American coal and 28 per cent. of the bituminous), the percentage cut by machines was 33.65, 35.95 and 35.57 respectively, and the corresponding death rates per million tons raised were 3.72, 4.10 and 5.18.

Now if we take a State cutting only a small percentage of its coal by machines, though producing a fairly large total amount of coal, such as Colorado, we find the deaths per mil-

TABLE III.

COAL-MINING ACCIDENTS IN THE UNITED STATES OF AMERICA IN 1902.

STATES (arranged in order of Col. 3).	Total output in long tons.	Percentage of bituminous mined by machines.	Total number of machines in use.	Total number of fatal accidents.	Accidental deaths per 1000 employed.	Tons of coal raised per fatal accident.	Accidental deaths per million tons raised.
Ohio	21,000,000	51.42	559	81	2.08	259,200	3.86
Kentucky	6,048,000	45.66	318	19	1 39	318,000	3.14
Pennsylvania :							
Anthracite	36,940,710	—	—	300	2.03	123,130	8.12
Bituminous	88,010,000	35.57	2620	456*	4.05	193,300	5.18
Indiana	8,430,000	25.63	269	24	1.55	351,200	2.85
West Virginia	21,890,000	23.35	579	159	4.48	137,800	7.24
Illinois	29,410,000	21.59	508	154§	3.35	191,000	5.24
Colorado	6,715,000	11.58	98	73	8.15	92,000	10.85
New Mexico	936,500	6.84	17	17§	10.0	55,100	18 15
Indian Territory	2,520,000	4.23	23	33†	5.92	76,400	13.09
Arkansas	1,736,000	0.46	7	13	3.62	133,600	7.49
All the States	269,277,178	26.75†	5148	1951‖	3.76	137,800	7.25‡
All England	227,095,000	1.83	483	1053	1.31	215,800	4.64

* This figure is abnormally high, but Mr. Parker does not comment on it.
† 23.50 per cent. considering the total coal (anthracite and bituminous) mined.
‡ 6.51 if the 200 killed in Tennessee are excluded.
§ Fiscal year ending June 30th, 1902.
‖ Including 200 killed by the explosions in the Nelson and Fraterville Mines, Tennessee.

TABLE IV.

COAL-MINING ACCIDENTS IN THE UNITED STATES OF AMERICA IN 1904.

STATES (arranged in order of Col. 3).	Total output in long tons.	Percentage of bituminous mined by machines.	Total number of machines in use.	Total number of fatal accidents.	Accidental deaths per 1000 employed.	Tons of coal raised per fatal accident.	Accidental deaths per million tons raised.
Ohio	21,800,000	57.31	865	118	2.57	183,200	5.42
Kentucky	6,750,000	47.46	453	19	1.37	355,000	2.82
Pennsylvania :							
Anthracite	65,250,000	—	—	595	3.69	109,600	9.13
Bituminous	87,500,000	35.92	3645	536	3.45	163,200	6.14
Indiana	9,750,000	33.33	403	34	2.70	287,000	3.49
West Virginia	29,100,000	29.40	901	140	3.08	208,000	4.81
Illinois	32,600,000	19.50	643	157	2.87	207,500	4.82
Arkansas	1,787,000	—	—	—	—	—	—
Colorado	5,950,000	14.21	125	89	8.26	67,000	14.95
New Mexico	1,298,000	6.89	12	15	7.61	86,500	11.52
Indian Territory	2,680,000	1.40	18	30	3.63	89,000	11.2
All the States	314,500,000	28.8	7663	1959	3.46	160,500	6.25
Great Britain	232,411,784	2.47	755	1017	1.2	228,700	4.38

TABLE V.

COAL-MINING ACCIDENTS IN THE UNITED STATES OF AMERICA IN 1905.

States (arranged in order of Col. 3).	Total output in long tons.	Percentage of bituminous mined by machines.	Total number of machines in use.	Total number of fatal accidents.	Accidental deaths per 1000 employed.	Tons of coal raised per fatal accident.	Accidental deaths per million tons raised.
Ohio	22,800,000	66.10	1041	131	3.03	194,189	5.75
Kentucky	7,540,000	51.44	527	—	—	—	—
Pennsylvania :							
Anthracite	69,400,000	—	—	644	3.89	120,590	9.27
Bituminous	105,700,000	41.66	4254	479	3.33	247,210	4.53
Indiana	10,600,000	35.37	506	47	1.86	253,090	4.43
West Virginia	33,760,000	33.09	1105	194	4.24	181,873	5.76
Illinois	34,350,000	22.63	882	199	3.47	191,156	5.80
Arkansas	1,728,000	—	—	8	1.91	241,834	—
Colorado	7,890,000	14.14	121	59	5.35	149,600	7.47
Indian Territory	2,612,000	1.37	29	40	5.19	73,111	15.4
New Mexico	1,470,000	—	—	5	2.35	306,860	—
All the States	350,820,840	33.2	9184	2097	3.53	174,524	5.97
Great Britain	236,111,150	2.915	946	963	1.122	245,500	4.08

lion tons raised are more numerous. Thus, in the three years 1900-2 Colorado cut 14.42, 5.60 and 11.58 per cent. respectively of its coal by machines, while the corresponding death rates were 6.20, 10.80 and 10.85. It is particularly instructive to compare the data for Colorado with those for Kentucky and Indiana, because the total output of coal per annum for each of these three States is nearly the same—namely, about six million tons. On comparing them we find the death rates in the latter two States far lower than for Colorado. The figures in column three of Tables 1 to 5 are arranged in descending order of magnitude, and in column 8 it will be seen that there is a distinct general increase as we look down the column. This means that the use of coal-cutting machines reduces the death rate per million tons of coal got.

Taking Tables 4 and 5, we see that in the years 1904 and 1905 Ohio mined 57.3 per cent. and 66.1 per cent. respectively of her coal by machinery, and that the accidental death rates per million tons of coal raised for the same State and years were 5.42 and 5.75 respectively. In the Pennsylvanian bituminous mines the corresponding figures were 35.9 per cent. and 41.7 per cent. of the coal was cut by machines and the death rates were 6.14 and 4.53. Then, taking a State such as Colorado, which mined only a small percentage by machinery, we have 14.2 per cent. and 14.1 per cent. cut by machines, while the accidental death rates were 14.95 and 7.47 respectively.

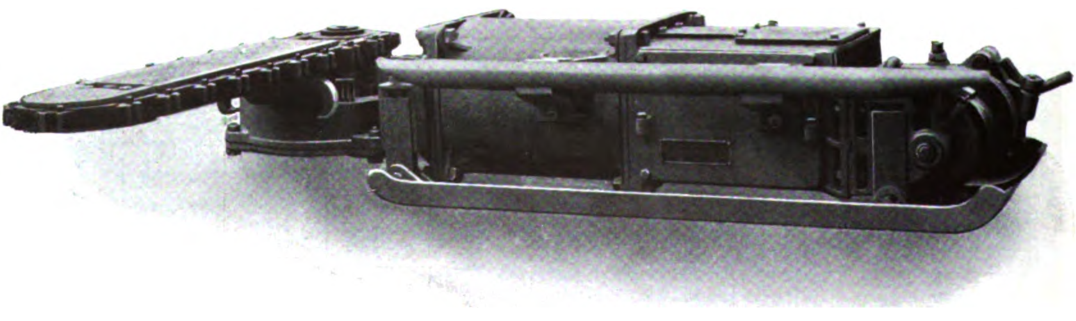


FIG. 1. CHAIN TYPE COAL CUTTER WITH ALTERNATE CURRENT MOTOR.

Coal Cutters, Haulages, Gears, &c.

ANDERSON, BOYES, & CO., LTD., are specialists in coal-mining machinery and devote their entire attention to this class of apparatus. The several illustrations herewith show the variety of their manufactures and serve to indicate the essentially modern nature of their designs. For instance the coal-cutting machines are well-known throughout the mining fraternity and have an established reputation for withstanding the rough usage to which this class of machinery is subjected. The machines are built in a large number of designs to suit different conditions. A few of these types are shown in Figs. 1, 2, 3, and 4, and it is suggested by the makers that they can rightly claim for them the largest coal output per annum for machinery of this class. The machines are suitable for either rails or skids, and are designed for heavy, continuous cutting in hard fire-clays. Machines are built to make either their own floor or hole at any reasonable height from the floor level. The electric coal-cutters can be supplied with either direct or alternating current motors with overall heights varying from 16½in. to 21½in. and suitable for undercutting from 3ft. to 4ft. 6in.

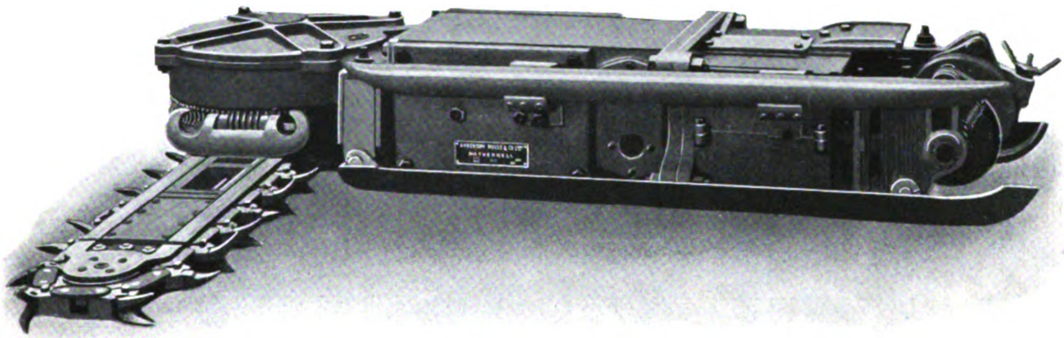


FIG. 2. CHAIN TYPE COAL CUTTER WITH DIRECT CURRENT MOTOR.

This company also manufacture electric winding and haulage gears, Figs. 5 and 6, and amongst their most important contracts for winding gears may be mentioned one recently supplied to one of the principal colliery companies in Scotland.

This particular winding gear is of the electric type, designed to operate on a vertical shaft of 40 fathoms with two cages. The load on each rope is 32cwt., exclusive of rope, which is ¾in. diameter. To suit the

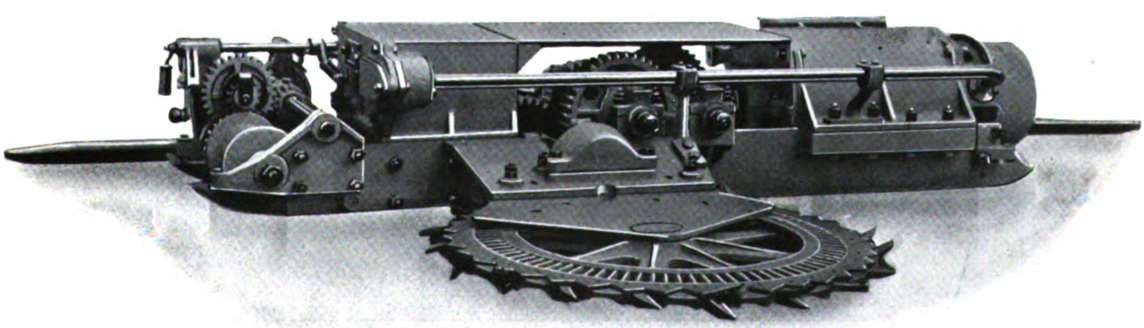


FIG. 3. DISC TYPE COAL CUTTER WITH ALTERNATE CURRENT MOTOR.

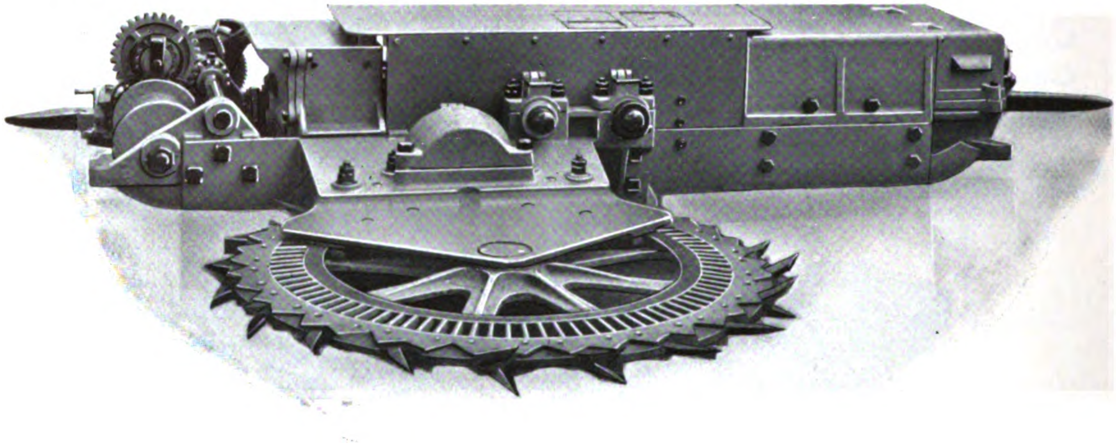


Fig. 4. Disc Type Coal Cutter with Direct Current Motor.

conditions laid down for an output of 37.5 tons per hour, the gear was designed to accelerate the load in 6 seconds, retardation 4 seconds, and 20 seconds for constant travel, which allows of a time pause of 42 seconds between each wind. The motor is of the shunt-wound, direct-current type with interpoles; it is capable of developing 120h.p. at acceleration and is controlled by means of a suitably designed reversing controller with ample resistance to regulate the speed of the motor through a large range, enabling such work as shaft and rope inspection to be carried out with ease. The indicator, which is of the circular type, is mounted on the main switch pillar, and is within easy reach of the man in charge. The main switch, which is fitted with a no-volt and overload release, is so arranged that it cannot be closed unless the controller is standing in the "off" position, and in the case of an overwind the same switch is immediately opened and operates a

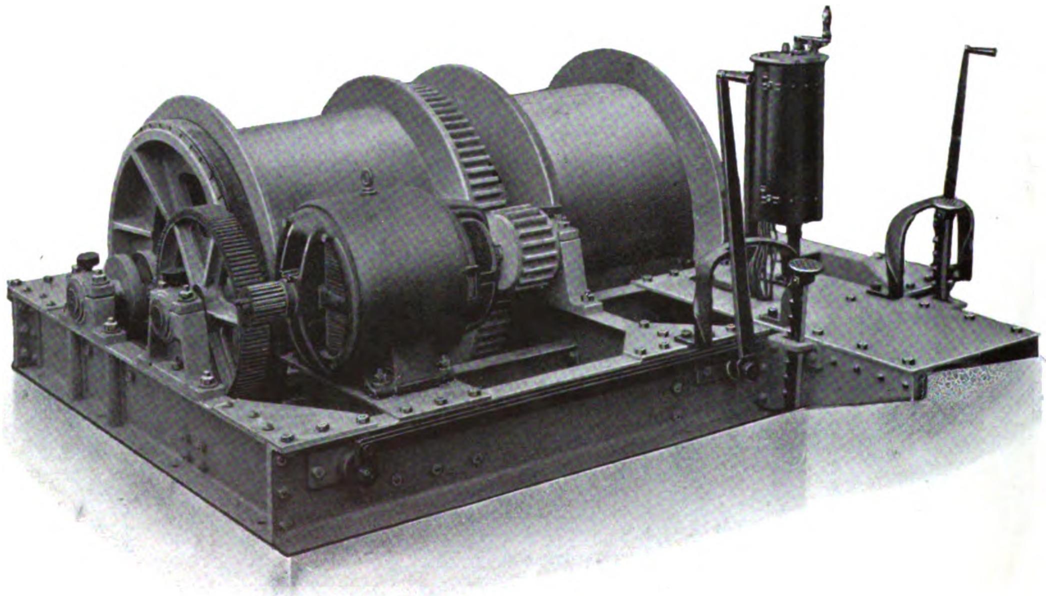


Fig. 5. Electric Haulage Gear.

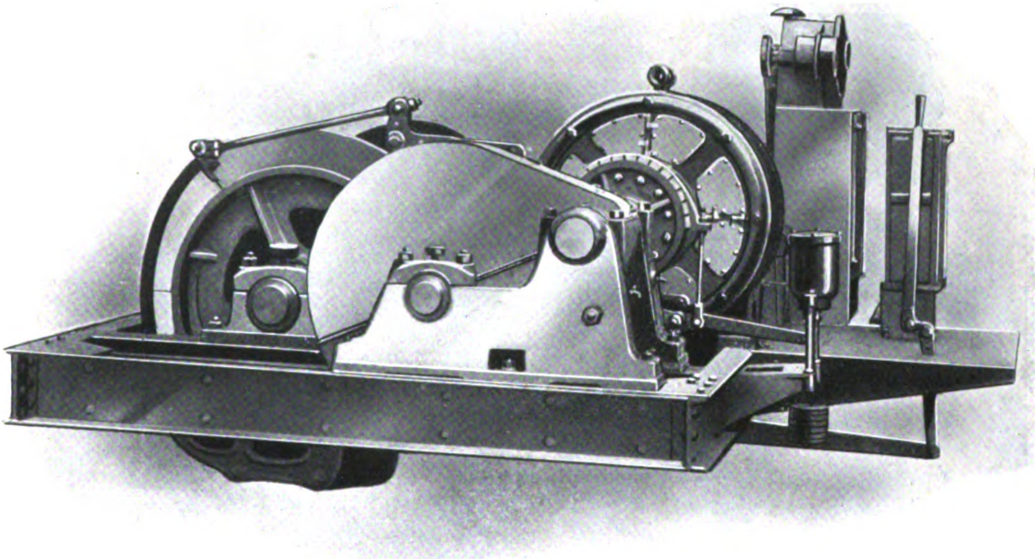


Fig. 6. Electric Winding Gear.

shunt-wound brake magnet fitted on an extension of the motor spindle. With this arrangement any interruption of the current immediately puts this brake into operation. A flexible coupling is fitted between the motor and its pinion, the extended shaft being provided with oil-ring lubricated bearings. The gearing is machine-cut throughout, the first motion being of steel, and runs in an oil bath. The main gear is of cast-iron of heavy design. The drum is 4ft. in diameter and is fitted with a powerful post brake operated

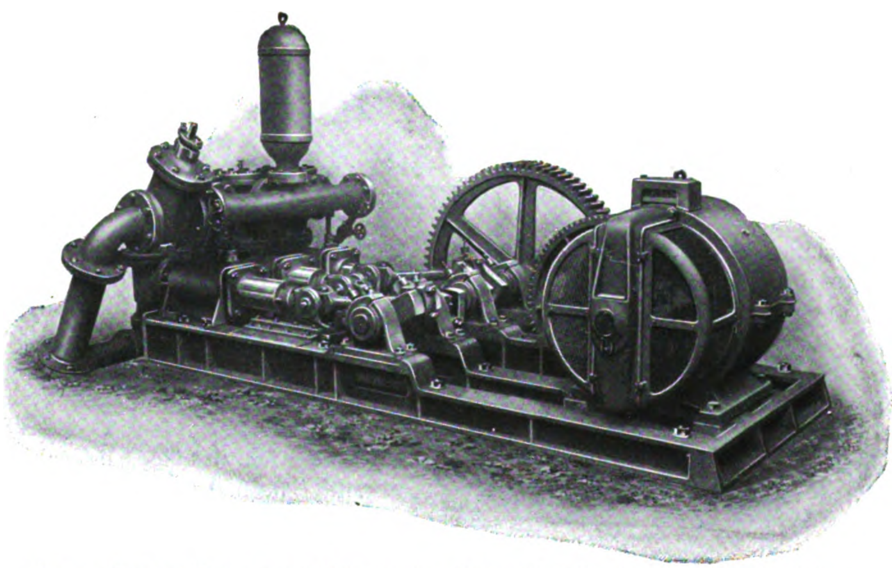


Fig. 1. Electric Three-throw Pump, 35b.h.p., Bibiani Gold Fields, Sekondi, West Africa.

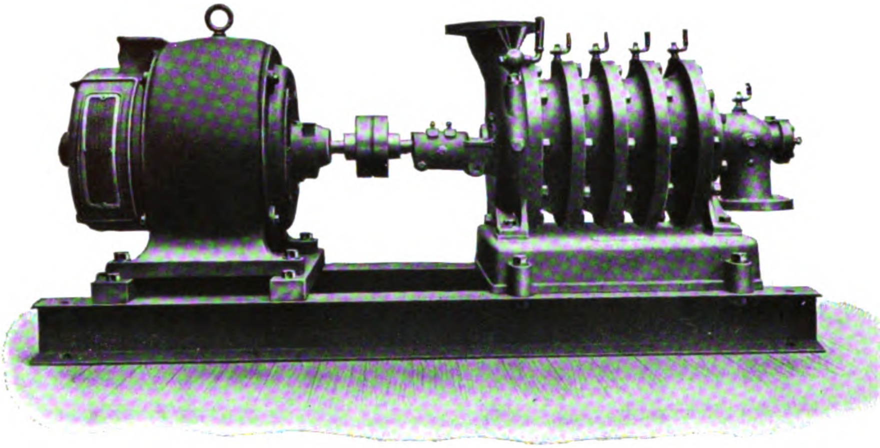


FIG. 2. ELECTRIC CENTRIFUGAL PUMP. BIBIANI GOLD FIELDS.

from the platform by means of a foot lever. The frame is built of mild steel and braced together by angle irons with turned and fitted bolts, all plates for plummer blocks and ends being machined. The complete gear is shown in Fig. 6.

At the present time the firm have on hand haulage gears of all types, ranging in power from 10h.p. to 100h.p.

Gold Mines Equipment.

Of the foreign mining contracts carried out by Messrs. J. H. Holmes & Co., one of the most important is that of the Bibiani Gold Fields, Ltd., for whose mines at Sekondi, West Africa, the plant supplied consists of three direct-current generating sets, and some ten motors which serve to drive saws, crushers, ram pumps, centrifugal pumps, conveyors, compressors, &c. On the preceding page Fig. 1 illustrates one of the triplex single-acting power pumps of this installation. In this case the motor, of the enclosed ventilated type, is of 35b.h.p. capacity, and the set is capable of delivering 12,000 gallons per hour against a vertical head of 400ft. The motor is started and stopped automatically by means of a relay switch actuated from a float. Fig. 2 shows a four-pole motor, enclosed type, 14b.h.p., 900r.p.m., coupled direct to a series horizontal five-stage centrifugal pump, capable of delivering 200 gallons per minute through a total vertical head of 120 feet.

RELATIVE VALUE OF GAS AND STEAM PLANT IN CONNECTION WITH COLLIERY WORK.

On examining the history of the application of gas to the production of power, one is struck with the fact that, although there has been no lack of technical and practical skill dealing with the various problems presented, nor any lack of capital in working out these problems commercially, yet, in spite of all these favouring circumstances, the application of gas to the production of motive power has been a slow process.

For over thirty years makers of gas engines have been grappling with the problem, and, while it must be admitted that a great deal of success has been attained with small prime movers, where high efficiency, great regularity in working, and other qualifications were not so necessary, throughout the above period, whenever engines of any considerable size have been installed, difficulties have constantly been experienced in keeping such plant running continuously and for long periods, as required for ordinary working, and it would not be hard to find

instances in all parts of the country where, in consequence, expensive plants have had to be scrapped.

For some years now, however, large gas engines have taken the field, embodying a number of improvements, and executed in the most approved manner by engine makers here and on the Continent.

One direction in which these large gas engines have been employed is that in connection with collieries, and a great deal has been done in various parts of the country in connection with such industries; but perhaps one of the best and most recent examples is that referred to in an important paper by Mr. E. M. Hann, of the Powell Duffryn Steam Coal Company, Limited, recently read before the South Wales Institute of Engineers, and for which he was justly awarded a gold medal.

The subject of the author's paper relates very fully to his experiments in the utilization of small coal, but in the course of his remarks he compares the relative results obtained from utilizing, on the one hand, gas from coke-ovens under steam boilers, and, on the other hand, its employment direct in the latest type of internal combustion engine; it is to this portion of the paper to which we wish more particularly to refer.

The gas is derived from modern regenerative coke-ovens of the Koppers type, and incidentally it may be mentioned that the heat value as given by Mr. Hann is about 460 B.Th.U.'s per cubic foot, 10,000 cubic feet of gas per ton of coal being produced.

In order to arrive at the value of the gas, a comparison is made with small coal of the calorific value of 12,000 B.Th.U.'s per lb., and a value at the pit of 5s. per ton. This result shows a minimum value of 1d. per 1000 cubic feet, or, allowing for lessened cost for stokers and ash men, &c., say 2d. per 1000 cubic feet; while, on the other hand, surplus gas is reckoned at 4d. to 10d. per ton of coal, allowing for 50 per cent. being available for power.

Owing to the presence of dust in the gas constituting a source of considerable trouble in the working of gas engines, the whole of the gas is purified. The result shows that with the gas engine working at full load (1200 b.h.p.), and consuming 21.3 cubic feet per b.h.p. hour, at the equivalent heat value of the coal taken by the author, 1 i.h.p. has been obtained from 0.7lb. of coal.

It is conceded by the author that unless the gas engine can be employed fairly continuously, and with a good load factor, it is not commercially economical.

This is an important admission of which too much notice cannot be taken.

Mr. Hann also states that in order to provide for fluctuations in the production of gas, and for temporary breakdowns, a gas holder of 300,000 cubic feet capacity was provided, and that it is intended shortly to duplicate this plant.

In comparing diverse systems such as those before us, there are naturally two considerations; first as to capital outlay and cost of working, secondly as to mechanical efficiency and durability.

Taking the question of cost, Mr. Hann states that the capital cost of a steam set of 825kw. with boilers was found to be £8,000 whereas gas plant for the same output represented £12,000.

In dealing with the relative cost of working, the author does not set out the actual figures for gas and steam in separate tables, but remarks that it seems to be conceded that one cubic foot of gas used in an engine cylinder develops as much power as 3 cubic feet burnt under a boiler. He then takes the mean of the two values already given, viz., 1½d. per 1000 cubic feet, and the consumption of gas in the engine shown by the test, of 25,500 cubic feet per hour for a practically full load of 820kw., and working on the above ratio arrives at a saving in cost of running in the case of the gas engine as compared with its rival, thus:—

Actual cost of gas, 25,500 cubic feet at 1½d. per 1000 = 3s. 2d. per hour.

Cost of steam on the assumption of 3 : 1 ratio, 3s. 2d. × 3 = 9s. 6d. Difference in favour of gas, 6s. 4d. per hour.

Or, taking 7200 working hours per annum, £2280 per annum.

The author afterwards deducts from this amount, however, the greater cost of attendance, upkeep and lubrication applicable to gas engine plant, and admits that his experience is scarcely lengthy enough to state confidently, but that applying his best judgment this would represent about £500 per annum, reducing the saving to £1780 per annum.

Mr. Hann makes a further statement, that if it were not possible to work near the full load, or if a less number of hours be worked,

a proportionate further reduction must necessarily be made.

This reduction might, in certain circumstances, be very considerable, so that one is unable to arrive at the precise advantage gained by the use of the gas engine.

It is a well-known fact, however, that gas engines working at anything below their rated capacity will not show the same economy as when working at their full load; also that they cannot be relied upon for an overload to any appreciable extent. It is also well known that gas engines will not work for the same long period as steam engines, without overhauling, while it takes longer to overhaul them than their rivals. There is also the unpleasant fact that a more considerable expense is incurred in the case of gas engines in the matter of spare parts, than with the steam engine.

On the other hand, very much higher relative efficiencies are obtained at low loads in the case of the steam engine, while it can be relied upon for a considerable overload, and altogether its capacity is far more elastic. These facts are not easily put into money value, but they must be taken into account by those who would fully weigh the whole subject.

In the discussion on this paper it was pointed out by Mr. Sugden that the author's statement that one cubic foot of gas used in an engine cylinder developed as much power as three cubic feet burnt under a boiler was one to which exception might fairly be taken, and that this ratio might perhaps hold good where the gas engine was of the latest and best type, and where the steam plant was only moderately efficient, or quite indifferent; but that comparing the most efficient plant of either system, the ratio of efficiency, although slightly in favour of the gas engine, would only be fractional, and that it was difficult to find any gas engine builder who would give a guarantee better than 0.9lb. of coal per i.h.p. per hour.

He took for example the Parsons turbines at Carville power station, Newcastle-on-Tyne; the steam consumption here was just over 13lb. per kw. hour on a 5000kw. unit, approximately equal to 8.5lb. of steam per i.h.p. per hour. Assuming 8.5lb. of steam generated from 1lb. of coal, this works out at 1lb. of coal per i.h.p. consumed. This, compared with the guarantee above mentioned, viz., 0.9lb. of coal per i.h.p., comes within 10 per cent. of the efficiency of the gas engine.

Mr. Sugden also remarked that the load factor already alluded to was admittedly a matter of great importance, and in this respect when less work is done the steam plant will show to greater advantage and the difference as regards efficiency will have been still further narrowed down.

It might also be pointed out that there are very few works where a high load factor, continuously maintained, can be depended upon.

Mr. Sugden mentioned a recent issue of the *Electrical Review*, referring to a discussion on the paper read by Mr. J. E. C. Snell, before the Institution of Electrical Engineers, on the cost of electrical power for industrial purposes. Mr. W. B. Esson gave the cost of electrical power for factory purposes, when served by an engine of 500b.h.p., having a load factor of 25 per cent., as follows:—

Total cost per unit:—

Mond gas	.516d.
Suction gas	.564d.
Steam condensing	.513d.
Steam non-condensing ...	.536d.
Oil	.592d.

Mr. Snell's figures were somewhat higher, because he averaged the cost of plants between 100h.p. and 500h.p., whereas Mr. Esson's were for the higher output. The agreement, however, was sufficiently close to show that under ordinary circumstances the total cost would lie somewhere between .5d. and .6d. per unit.

Mr. Sugden claimed for the steam plant that it is more reliable, with lower cost for maintenance charges, and lower running charges.

On the important question of depreciation he saw no allowances in the author's figures to provide for this, as the £500 already alluded to was intended to cover the extra cost of attendance, upkeep, and lubrication, and it is generally admitted that a larger depreciation is needed for a gas-engine than for a steam plant.

Although no reliable data exist as to the life of gas-engine plants, it is an unfortunate fact that in the numerous electric light stations where gas-power was first installed, steam-power has been adopted either in full replacement of the original gas-plant, as in the case of Belfast, Leyton, Redditch, Walthamstow, Johannesburg; or when extensions were necessary steam-plant was employed, as in the case of King's Lynn,

Reading, &c. This seems to show that steam engines are more reliable.

The difference in capital cost is estimated by Mr. Hann at £4000 more for the gas-plant (£12,000) than for the steam-plant (£8000), but, as Mr. Sugden showed, it is necessary to allow in addition for the extra cost of foundations and buildings, as steam turbines require smaller foundations and buildings, and it would appear, in addition to these costs, that of a 300,000 cubic feet gas-holder should be added.

The type of coke-ovens selected—viz., those of the regenerative form — is also dearer than the ordinary waste-heat coke-oven, which would also go to increase the difference in the capital cost in favour of steam.

At the Liége Exhibition of 1905 Mr. Sugden saw a very complete installation of colliery surface machinery and coke-ovens shown by the Harpen Collieries Company, Ltd., a concern raising 700,000,000 tons of coal and producing more than 1,000,000 tons of coke per annum, all in by-product ovens. The company was naturally greatly interested in the question of economy of power in connection with coke-oven plants, and published the results of their experience in a valuable pamphlet describing their exhibits. This pamphlet gave detailed particulars of their coking plant at Scharnhorst, more especially dealing with the question of surplus gas, either for steam raising or for direct use in internal combustion engines, indicating that they had carefully considered the problem dealt with in Mr. Hann's paper. Experiments were conducted to show the cost of working under gas or turbine plant; they started their calculations on the basis of coal at 9s. per ton.

The actual cost in detail of producing 1200h.p. in a gas-engine per hour, as given by the Harpen Collieries Company, is as follows:—

		s.	d.
Gas consumption for engine ...		4	11½
Attendance		3	2½
Lubricating oil		0	9
Stores...........		0	6
Interest and depreciation (16 per cent.)		12	5
	£1	1	10

The cost of the same power by means of steam turbines, worked out by the same company, is as follows:—

		s.	d.
Gas consumption for boilers ...		13	2
Attendance		1	7
Lubricating oil		0	1¼
Stores		0	0¾
Interest and depreciation (12 per cent.)		5	2½
	£1	0	1½

It will be observed that the amount allowed as the result of the Harpen Company's experience for interest and depreciation is 16 per cent. for gas-plant and 12 per cent. for steam-plant. If, therefore, as it would seem, no depreciation was allowed for by Mr. Hann, the difference on the basis of the 4 per cent. mentioned above, spread over 7200 hours, would amount to £960, or 2s. 8d. per hour. The Harpen Company show a saving in fuel through motors of 8s. 2½d. per hour; this variation is no doubt largely due to the difference in the price of coal on which the figures are based.

Mr. Sugden points out that according to the Harpen Company the capital cost of gas-plant is £12,000 more than for a steam-plant for 1200h.p., a difference considerably in excess of that named in the paper, while the running expenses are more in the case of gas, as shown above, than for steam.

It will be noticed in this connection that, in the case of gas-plant, lubrication and stores, on the Harpen Company's showing, amount to 2s. 9d. per hour more than a steam-plant; if this be multiplied by 7200 hours, the result would be nearly double the £500 allowed by Mr. Hann for extra cost of attendance, upkeep, and lubrication.

M. Leon Greiner, Engineer of La Société Cockerill, another investigator in the same field, in his paper entitled "Production Economique de la Force Motrice," says, referring to the economy which he claims in the working of gas engines, "but this economy is only real in so far as the gas can be employed at once to produce motive power, and that this power can be utilised immediately"; and he then goes on to state that it is not possible to store large volumes of the gas produced for any length of time, and therefore if gasometers be used, they can only serve the purpose of regulators for reducing the variations in the supply throughout the day. It will be observed that Mr. Hann has employed a gasometer in this way.

On the relative output of gas used

in an engine compared with that from the same quantity burnt under a boiler, M. Greiner states that, taking a given quantity of gas, its utilization direct in an internal-combustion engine represents two to two and a half times the power developed by steam engines. If this ratio be accepted as the basis instead of the three to one mentioned by Mr. Hann, a considerable difference appears in the result and in favour of steam.

Taking a mean of the two figures given by M. Greiner, *i.e.*, 2¼ to 1, the figures reconstructed from the above remarks would be:

	s.	d.	s.	d.
Gas per hour as before	3	2		
Steam in the ratio of 2¼ to 1 = 3s. 2d. × 2¼	7	2		
Apparent difference in favour of gas per hour			4	0
Allow:				
Cost of attendance, upkeep, and lubrication, estimated by Mr. Hann $\frac{£500}{7200 \text{ hours}}$	1	4½		
Extra for these services estimated by Mr. Sugden and based on the Harper Company's figures, viz., $\frac{£500}{7200 \text{ hours}}$	1	4½		
Difference in depreciation in favour of steam-plant, 4 per cent. ..	2	8	5	5

thus showing that the estimated saving by the use of gas-plant has disappeared, leaving a balance in favour of steam, apart from the advantages due to better efficiency in the case of lower load factors, overhauling, &c., which cannot easily be rendered into figures.

Another investigation on the question as to the relative superiority and cheapness of cost in working of steam and gas may be mentioned, viz., that of the Bury Corporation Electric Lighting Committee, quoted in the *Bury Guardian* of the 6th June, 1908.

In this case the gas-engine makers dealing with a 1000h.p. plant working at full load would not guarantee less than 2.2lb. of Lancashire "slack" per B.O.T. unit generated.

On the other hand, they state that tenders obtained under guarantee from makers of steam turbine generators, after making a very liberal allowance for steam consumption on small auxiliaries and for losses between boiler and engine, amounted to practically the same as the gas-engine plant, viz., 2.2lb. of Lancashire "slack" per B.O.T. unit.

The question of cost of oil and wages in this report is dismissed with the remark "that anyone acquainted with the design and relative size of a large gas engine and a steam turbine would be very unlikely to contend that the turbine would be more costly in oil and attention, in fact there can be but little doubt that the gas engine would cost the most."

On the question of capital cost, their report states that the estimates received fully bore out their contention that to instal a gas plant would cost about £22 per kw. as compared with £13 9s. per kw. for the first instalment of steam plant and £11 1s. per kw. when the buildings were fully occupied.

Another instance of the economical working of steam engines may be quoted. At the Hague Electricity Works a test was carried out recently with a 1500kw. generator, under a guarantee that not more than 0.9 kilo of coal should be used for the production of 1kw. hour of electricity at the *switchboard*, thus covering all station losses up to this point. In the result it was found that 1kw. hour was produced by the expenditure of 0.839 kilo of coal; in other words 1.845lb. of coal per kw. hour or 1.22lb. per i.h.p. hour.

No doubt this performance would have been still further improved if the size of the units had been 5000kw. instead of 1500kw. In any case these figures show that the ratio of output in the case of gas and steam, correctly estimated, would work out more like 1¾ to 1 if the Hague Electricity Works figure be taken, without considering the further improvement by the use of larger units.

The existing differences between gas and steam, whatever they may be at present, are likely to be varied as time goes on; engineers on both sides, gas and steam, are working their hardest towards the irreducible limit. This limit, in the case of gas engines, seems to be imposed by the question of temperature, and on this point the editor of a well-known technical paper has pointed out that "this fact (of elevated temperature) has stood persistently in the way of the gas engine, and still bars its way to the position of the most important prime mover. Without a high temperature, a high mean effective

pressure is not possible, and with a high temperature we are visited with all the ills and troubles that great heat brings in its train; hence we have to content ourselves with a low temperature and a larger cylinder, and it is only necessary to note the immense size and weight of the large gas engines for the power they develop, to feel a conviction that unless some way out of the quandary can be found, the gas engine cannot advance much further."

In the case of the steam engine the tendency is towards effecting further economies by the increase of temperature in the use of more highly superheated steam; thus the amount of steam consumption per h.p., while it has been greatly reduced in recent years, bids fair to still continue to beat its former record, while in the important considerations of weight, space, and simplification of parts, the steam turbine and its latest development, the exhaust steam turbine, have led us to feel that the limit in efficiency has by no means yet been reached.

THE RATEAU SYSTEM OF POWER GENERATION FROM EXHAUST STEAM.

Of late there has been a very considerable amount of work done in the reclaiming of the large powers usually dispersed to waste in the exhaust of the heavy power engines of mines and steel works. The common type of winding engine running with high-pressure steam and exhausting to atmosphere is by itself an extremely inefficient power unit. It has for many years been apparent that some means of collecting and utilizing the considerable energy carried in these high-pressure exhausts would introduce great economies in the working cost of an establishment. With the development of the steam turbine it became evident that here was a machine suitable in every way for operation, in conjunction with a condenser, at a steam supply of atmospheric or slightly higher pressure, but to adapt the low-pressure turbine for operation with the exhaust steam of winding or rolling mill engines meant facing the difficulty that such a steam supply is extremely intermittent. It became necessary, therefore, to devise some means of levelling the pressure or supply of the exhaust steam available so that the turbine should receive steam supply constant in pressure and volume. Prof. Rateau, of the School of Mines, Paris, invented and patented what he terms heat accumulators, which, interposed between the main engine exhaust and the turbine supply, serve the purpose of economically receiving and storing the exhaust steam, giving up a constant pressure supply to the turbine. The first working application of this system was made in France in the year 1902 and its success is well exemplified by the very many similar installations which are now at work in this country, on the Continent, and in America. The first plant to be put down in Great Britain was that of the Steel Company of Scotland for their Hallside works in May, 1905. Since that date Mr. P. J. Mitchell, who controls the Rateau patents in this country, has altogether put down or received orders for some 20,000kw. of plant.

As will be readily understood, the accumulator is the essential feature of this modern means of generating power from exhaust steam. This invention is based upon the well-known principle regarding the reciprocal action of saturated steam and steam-saturated water: when these two fluids are brought together they preserve a state of equilibrium, and any variation in this balance determines the transformation of either steam to water or water to steam with a definite heat liberation or absorption respectively. This principle is applied in a number of types of

accumulator, any one of which may be adopted as desired by the engineer or as deemed expedient under certain local conditions. The most usual form of accumulator, known as the water type, consists of a cylindrical shell carrying two or more oval perforated tubes running throughout its length. The main engine exhaust feeds into the oval tubes and is spread or dispersed into the water which just covers the tubes, a baffle plate over the tubes serving to prevent priming of the accumulator, from the upper portion of which steam is drawn direct for the turbine supply. Several of these accumulators may be used where large powers are handled, or a large single accumulator can be arranged with two or more compartments divided off bya suitable horizontal diaphragm. The accumulator is fitted with the necessary special automatic relief valves, draw valves, water level regulators, gauges, &c. As will be understood, the arrangement of the long, finely perforated tubes ensures the thorough and rapid circulation of the water. In other types the circulation of the water has been obtained by means of steam injection, pumping water over trays, and mechanical agitation.

Another type of accumulator which is giving every satisfaction in use is one which consists of an enclosed vessel packed with a very large quantity of scrap iron so that an enormous surface of metal is interposed in the main engine exhaust. Thus in some few cases where old rails and other similar metals abound an old boiler shell has been packed with these and served very well as an accumulator. It will be evident in this case that the regeneration depends upon the quantity of water condensed by the mass of rails and held up in the interstices between them. Such an accumulator is in use at the Hucknall Torkard Colliery.

As of particular interest to mining men it will be as well to give some particulars of the plant which has been working for about two years at the Auckland Park Colliery of Messrs. Bolckow, Vaughan & Co. This plant was installed because the demand for electrical power had increased to such an extent that it meant either putting down additional power generating plant or introducing very considerable economies in the plant existing. The latter system was decided upon and the Rateau principle introduced.

The engines from which the steam was exhausted to the atmosphere were as follows:—

Two winding engines, four hauling engines, one fan engine, two washery engines, one conveyor engine, one crusher engine, one screen engine.

The maximum quantity of steam available is 43,500lb. per hour; the approximate loss through condensation in the piping, 10 per cent.; and loss through radiation in the accumulator itself one per cent.

The hauling engines exhausted into three old boiler shells, egg-ended, arranged as feed heaters, and as the supply of steam was sufficient the arrangement was not disturbed; but the steam leaving the heaters was coupled into the accumulator.

One winding engine was not coupled, but when the second unit is installed this engine will contribute its exhaust to the Rateau plant.

The engines at the colliery are very scattered, necessitating very long connecting pipes. No. 2 winding engine (of the vertical single-cylinder type) is distant from the turbine house about 135yds., and the pipe conveying the steam to the plant is 15in. diameter wrought steel riveted. The pipe is carried above ground on trestles and passes the feed heaters mentioned. At this point the steam from the hauling engines joins it, the connecting pipe being provided with a non-return valve, and the diameter of the pipe is increased to 18in. About 30yds. from this point No. 1 winder is installed, of the two-cylinder horizontal hand cut-off type, and the exhaust pipes are led into the main. The accumulators are immediately at the side of the winding engine house, between it and the turbine house. The exhaust steam pipe from the various engines is connected to a Holden & Brooke exhaust steam separator to remove any oil that may be in the exhaust steam, and to this separator the steam from the fan engine is also led. There are at present three "Willans" engines in use at the colliery, but since the installation of the Rateau plant these engines have not been in operation during the daytime, the turbine taking the whole of the day load. A connection to the accumulator has been provided for these engines also.

The steam separator is connected to the 24in. main passing across the top of the accumulator. This consists of three vessels (two only were installed for the first unit).

about 7ft. in diameter, and 30ft. in length; each vessel is fitted internally with two D-shaped tubes, the adjacent sides (which are flat) of each tube being drilled with three rows of holes, the diameter of the holes in each row varying somewhat.

The holes do not occupy the whole length of each row, but are arranged to ensure the distribution of the steam over the whole length of the vessels being uniform.

The flat sides of the D tubes are extended downwards, whilst diverging to within about 17in. of the bottom of the shells, to ensure that the body of water at the bottom of the vessels shall participate in the circulation, and consequent regenerative action, of the accumulators. Baffle plates are arranged to prevent priming, and scum trays and automatic water-level regulators are fitted.

The water-level in the shells is, when the water is at rest, 13in. above the level of the top row of holes, and the fluctuation observed is about 4½in. to 6in.

The water is sufficient in quantity to ensure that during engine stops of sixty seconds, with a temperature fluctuation of 7deg. F., sufficient steam will be regenerated to generate 1000kw. without the necessity of using the automatic live-steam bye-pass.

The steam, on leaving the accumulators, is collected by a 22in. diameter riveted steel pipe, into which the live-steam bye-pass from the two 6in. reducing valves is connected. The pipe then passes downward into the basement of the turbine house, and is connected to the stop valves of the turbines.

At present only one turbine is installed, this being a unit of 500kw. capacity.

The turbine is of Prof. Rateau's multicellular type, and has eight wheels of about 40in. diameter. The governing is by a very sensitive but powerful governor (of centrifugal type), acting on a simple double-beat balanced throttle valve, the governor being provided with a Picard compensator to ensure a minimum speed variation from normal at any load.

The maximum momentary variation, when the whole load is thrown off and on, is only 7½ per cent., and the permanent variation 1½ per cent. to 2 per cent.

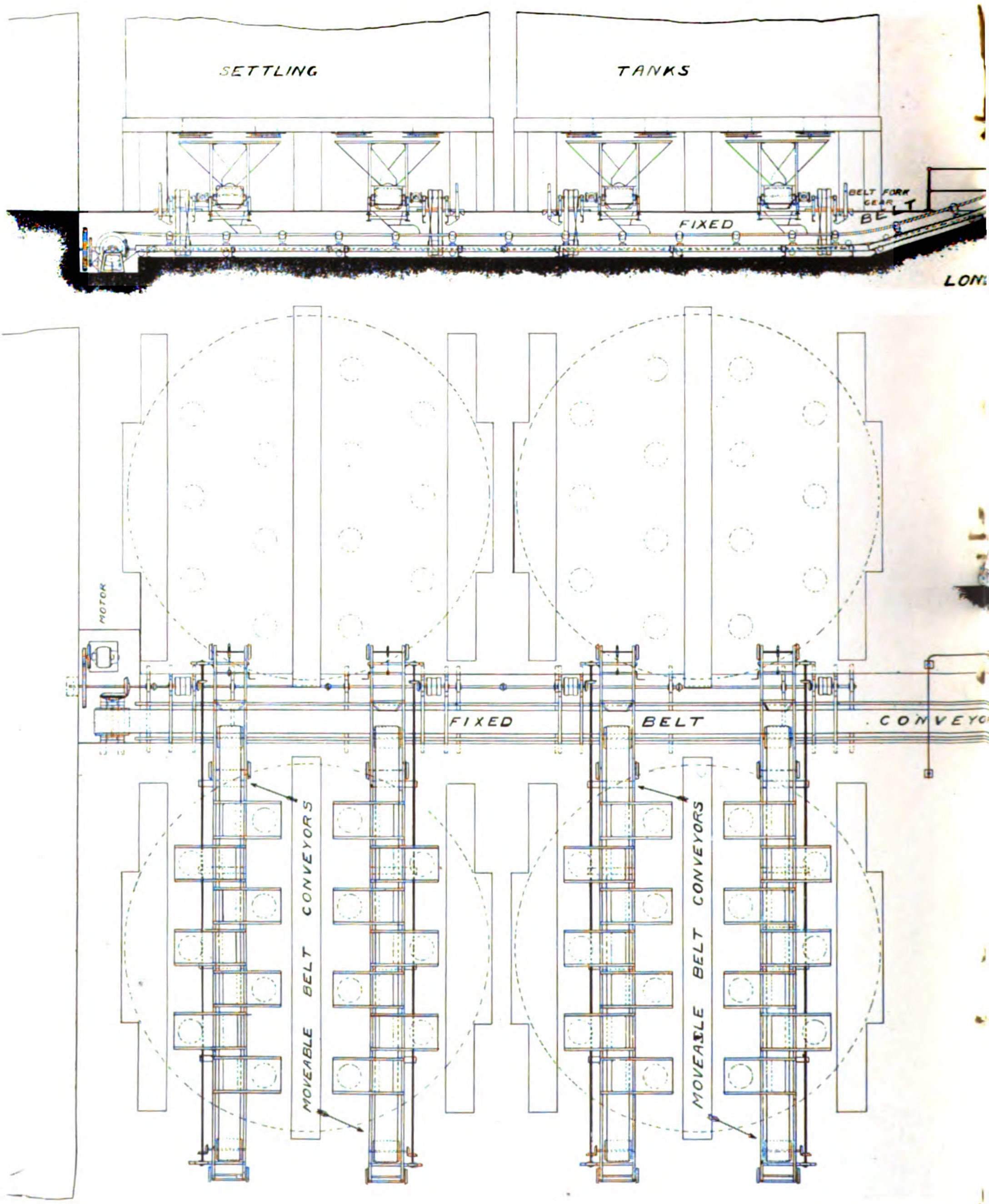
The turbine is designed to give 30 per cent. overload at normal speed, 1800r.p.m., without the use of a bye-pass, and when exhausting to a 27in. vacuum.

Lubrication is forced, the oil being pumped to an overhead tank about 25ft. above floor level by a rotary chain-driven pump; each bearing is provided with a "Whitmore" patent sight-feed adjustable lubricator fitted with a filter. The consumption of the turbine on full load is approximately 39.5lb. per kw. hour.

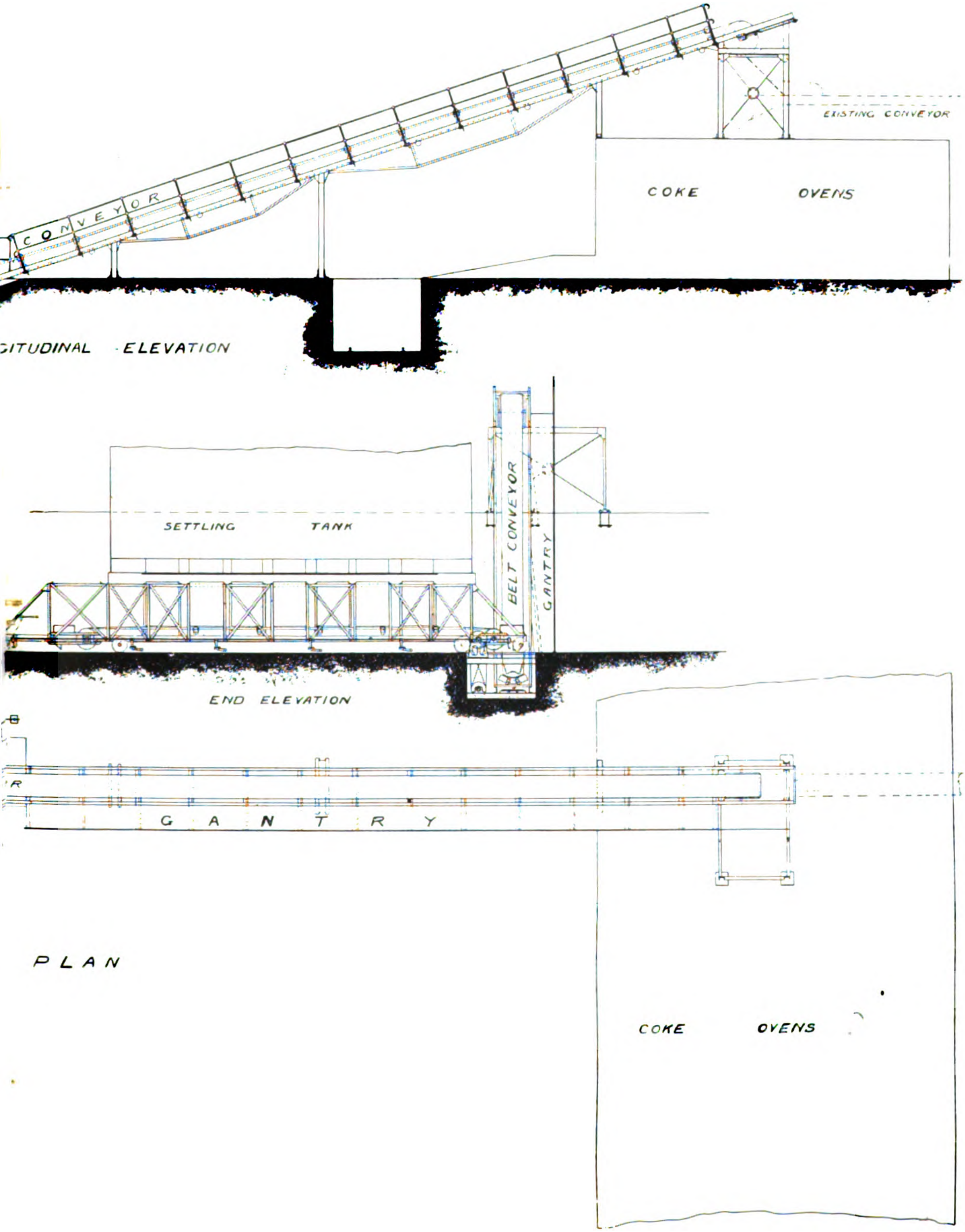
The alternator (by Messrs. Siemens Brothers, Ltd.) is designed to give 500kw. three-phase current, 40 periods, 2400 volts, at 1800r.p.m. The rotating field is of the smooth-type bar, wound in slots. The ventilation of the machine is excellent; the temperature rise, after six hours' run at full load, being about 70deg. The stator is completely enclosed, the air being drawn in at one end of the machine by a fan cast in one with the end shields of the rotor, and forced axially through the holes in the field and slots behind the windings, both on stator and rotor.

A little trouble was experienced at the works with the exciter, the commutator surface being too small, and it was decided to replace it. This was done as soon as possible after the machine was erected, and during the period between the setting to work of the plant and the arrival of the new exciter, the trouble expected from heating and cutting of the commutator duly showed itself, although it did not prevent the plant being run successfully on the works load at about three-quarter load.

The condensing plant (by Messrs. Mirrlees, Watson, Ltd.) is designed to handle 44,000lb. of steam per hour, and to maintain a vacuum of 27in. with the barometer at 30in., and is of the barometric jet type. The condenser body is of the vertical type, fitted with trays over which the water falls, meeting the steam, which enters the condenser near the bottom; the air and uncondensable gases rise to the top of the vessel, and are drawn off through a water separator by a double-acting, single-throw, dry-air pump of the slide-valve type, with cylinder 16in. diameter by 15in. stroke, gear-driven by a 15b.h.p. three-phase motor. The pumps run at 115r.p.m. When the second turbine is installed, a second pump will complete the equipment, and one pump will just keep the turbines running at full load, whilst any slight repairs, such as changing valves, &c., are made to the other set. The condenser requires about 1800 gallons of water per minute when condensing 22,000lb. of steam at 27in. vacuum with water at 85deg. F.



THE REDDAWAY BELT CONVEYING PLANT AT



IE WORKS OF THE CARLTON IRON COMPANY.

The turbines are connected to the condenser by a 36in. riveted steel pipe.

One pair of centrifugal pumps are at present installed, and a duplicate set will be added when the second turbine is laid down.

The pumps are of the side section type designed by Prof. Rateau, and are of high efficiency for a low lift pump, about 67 per cent.; they are arranged one on either side of a three-phase motor of 50b.h.p. One pump takes the water from the hot-well of the condenser and delivers it through a long range of piping to a "Richardson Westgarth" cooling tower, and the other takes the cold water from the tower, and forces same to the condenser, being assisted, of course, by the vacuum in the latter.

The two sets of pumps are arranged below ground level in a pit, and the starters and control boxes, which are of the mining type enclosed in C.I. boxes, are placed on the wall in the pump house.

The second unit will be of the mixed pressure type of 500kw. capacity, capable of working entirely or partly on exhaust or live steam.

The system of forced lubrication used on the installation was a new one, and a few difficulties were encountered at the commencement which were, however, soon overcome, and the plant has now been running for over three months to the satisfaction of Messrs. Bolckow, Vaughan & Co., who have placed orders for a very large installation for their steel works.

THE BELT CONVEYING PLANT AT THE WORKS OF THE CARLTON IRON COMPANY.

This coal-handling equipment is of a unique design, as will be readily recognised on making reference to the drawing given on pages 122 and 123. Primarily the plant is for conveying the small coal, after it has passed through the washers, from the settling vats or tanks to the existing coke oven plant, which is of the modern regenerative and bye-product recovery class. The claim of the unique design of the conveyor plant is justified when it is explained that the four cross conveyors under one set of settling tanks are so arranged that they convey the coal from either set to the central conveyor. They are placed at right angles to the central conveyor, and being made movable and reversible can be transferred to the other side of the central conveyor, under the opposite tanks, and perform the same operations in a reverse manner.

The conveyors are entirely automatic with the exception that hand-gear is provided to each of the cross-conveyors for moving from one position to the other. This, however, can be easily done by the attendant of the plant.

Each tank is fitted with openings and doors in the bottom, to the number of fourteen in each settling vat, these openings connecting to each conveyor. Any one of these doors being opened allows the coal to pass down through the chute fixed to the framework and movable conveyors to the belt, which then conveys it to the long conveyor in the centre. This conveyor carries it along and up the incline, delivering to the hopper of the compressing machine.

Attention should be drawn to the arrangement for driving this plant and particularly to the method by which the reverse driving of each of the cross conveyors is accomplished. Needless to add, the plant is driven by electric motor, which is worked at the rear end of the long conveyor, shown on the plan view of the drawing given. The drive is effected by means of connecting the motor to a shaft fixed in the conveyor trench, transmitting the requisite power, by means of open belt drives, to short counter shafts, thence through bevel wheels with square shafts and rocker bearings for driving in one

direction, and by means of cross belt drives for the reverse direction.

The capacity of this plant is 800 tons per day of ten hours, but provision has been made for considerably adding to this amount when future extensions are made. In fact, the conveyors installed are quite capable of carrying double the capacity named above. The complete equipment was designed, manufactured and erected by F. Reddaway & Co., Ltd., Pendleton, Manchester, who have for many years made belt-conveying appliances a special feature of their work in connection with machinery used for transporting purposes. The chief feature of this firm is that they not only make the mechanical portions of the plants in their own works, but also the belts, and as the variety of their manufactures in the latter direction is so large, one is assured of getting the best class of belt for the particular purpose in hand.

In addition to the important contract illustrated here Messrs. Reddaway have recently completed several others, the largest amongst them being for the Consolidated Gold Fields of South Africa, Johannesburg; Sheffield Coal Company, Sheffield; John Brown & Co., Ltd., Rotherham; Great Western Railway Company, Fishguard.

The particular features claimed for belt conveying apparatus as compared with the ordinary type of conveyors, made entirely of steel, are as follows :—

No noise, no friction, few wearing parts and these all interchangeable, automatic and continuous discharge, small horse-power required to operate, large carrying capacity, and low working costs.

ELECTRIC SINKING PUMPS.

THERE is probably no single plant which is more typical of modern machine development than the electric centrifugal sinking pump with its perfect balance, small dimensions, direct drive, and high efficiency. As will be readily understood, the conditions under which the sinking pump has to operate are of the most trying character; compared with the pump of fixed or stationary type, it is denied of any steadying foundation, and it is further called upon to be the support of its driving engine or motor, and of some greater or less length of the suction and delivery mains. Suspended in the shaft, it is to a large extent inaccessible, and it is subject to falling debris, flooding by water, and generally rough conditions of surroundings and attendance. Its position is frequently altered, following the progress of work, and in short, the wonder is that any machine of parts will operate consistently or at all well under such circumstances.

In the series of illustrations given herein the progress made in the design of sinking pumps is made evident, although all the types shown can still be rightly classed as present-day machines. Figs. 1 and 2 show the most improved types of vertical steam-driven sinking pumps as made by the Worthington Pump Company, and illustrate the pains which the designers have been at to secure a compact and balanced machine. The "Palmer Special" sinking pump, Fig. 1, is designed to secure the greatest possible pumping capacity in a minimum space, and is especially adapted to the recovery of flooded mines and general excavating work requiring a very compact form of pumping apparatus. The arrangement of steam cylinders adopted in this style of pump secures twice the capacity (theoretically) of one of the ordinary type occupying the same shaft space, while since there is practically no increase in the number of moving parts or amount of internal friction, it is claimed that more than double the ordinary duty is obtainable in actual service. There are two steam cylinders, precisely alike in size and action, placed tandem, their pistons being directly connected to the rod actuating the water plunger. In the size shown in the illustration these cylinders are each

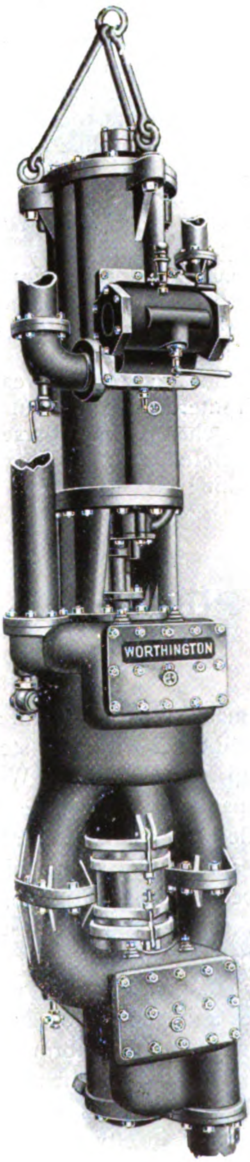


FIG. 1. "PALMER SPECIAL" STEAM SINKING PUMP (WORTHINGTON).

16in. in diameter, and the double-acting plunger is 12in. in diameter, giving a capacity of 489 gallons per minute at 100ft. of piston travel. The common stroke of steam cylinders and plunger is 20in., and the speed of piston travel can easily run up to 125 or 150ft. per minute in case of emergency, corresponding to a delivery of 608 to 729 gallons per minute, a capacity of more than twice that of any other type of steam pump which can be passed, endwise, through the same opening.

The "Bucket and Plunger" type of Worthington sinking pump, shown in Fig. 2, is adapted for sinking new shafts, recovering "drowned-out" mines, and for general excavating work involving a variable water level.

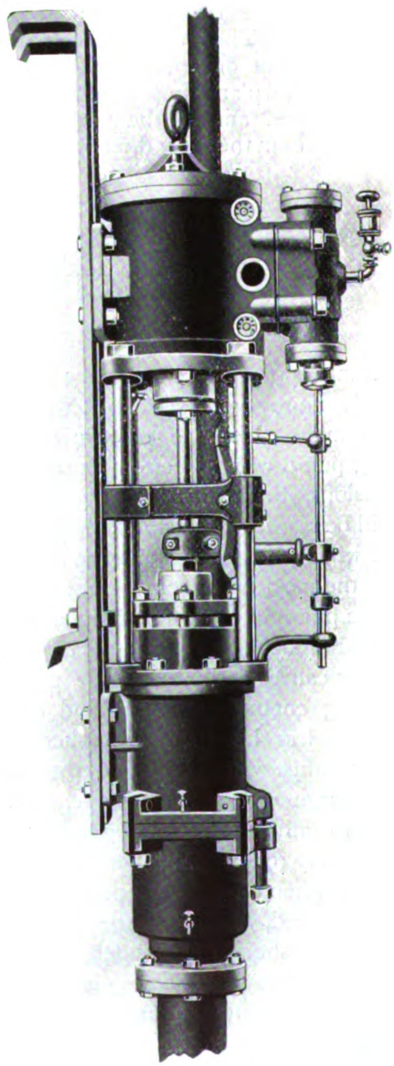


FIG 2. STEAM SINKING PUMP (WORTHINGTON).

It is compact, easily handled, and, while designed to work in a vertical position, will operate satisfactorily at any desired angle, either suspended by a tackle or hooked to the shaft timbering. Each pump is fitted with a ring bolt, firmly imbedded in the cylinder head, for hanging by tackle, and with adjustable wrought-iron dogs bolted to cylinders for hanging from shaft timbers.

Comparing these two examples of high-grade steam-driven sinking pumps with the electric pump shown in Fig. 3, it is apparent that the substitution of the rotating electric motor for the reciprocating steam pistons and valves makes for greater reliability. This pump is light in weight, compact in form, very efficient, and of good capacity, and is not liable to damage from moisture or hard usage. The motor with its gearing and operating mechanism is enclosed in a tight casing, the only moving parts visible being short sections of the plungers and rods, but every part of the motor and pump is readily accessible for examination or repairs, and can be quickly and easily replaced. Should a sudden inrush of water in the mine completely drown the pump, it will continue to work without being affected in the least, if provided, as shown in the illustration, with a totally enclosed type of motor; the pump will work as well under water as out; in fact, the cooling action of the water is rather an advantage than otherwise. There are no exposed working parts liable to damage, or to cause injury to those who may be working about the pump. This type of pump is really intermediate between the older steam-driven ram pumps and the latest electric pumps, which are of the direct-coupled centrifugal type. Fig. 4 illustrates one of the most important sinking pump installations of the present time, which was put down for the unwatering of the Tywarnhaile Mine, Cornwall. In this case the pump shaft is about 180ft. from the electric power house, and cables of the three-core, lead-covered and armoured type serve for the pump motor supply, the cable passing over a drum placed near the pit mouth.

The gas producers are erected immediately outside the engine room, and the coal is delivered on a platform built at a level with the top of the producer, from which it is payed out or taken in easily by manual labour as required by the position of the pumping set.

Slip rings are attached to the end of the cable, which is securely fastened to the drum,

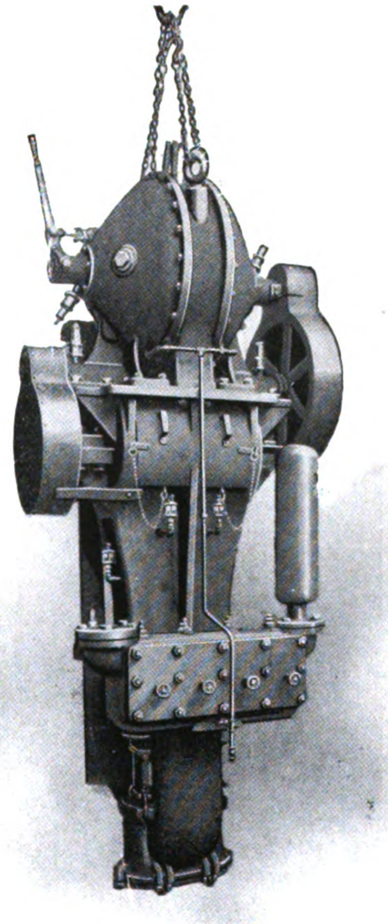


FIG. 3. DOUBLE-ACTING ELECTRIC SINKING PUMP (WORTHINGTON).

and these in turn are connected to the feeder panel by means of a joint box. The cable from the drum is led through one of the legs of the head-gear, direct over a $4\frac{1}{2}$ft. pulley down the shaft to a joint box securely attached to the pump frame. The leads are taken from the joint box direct to the vertical motor operating the pump. No difficulty has been experienced in handling the cable, and, in fact, the arrangement has been satisfactory in every way.

An auto-starter is fixed near this drum and the starting and stopping of the pump is therefore done at the surface. On the top of the shaft a head-gear 25ft. in height has been erected, together with a large motor-driven capstan of sufficient power to ensure a very easy handling of the pump, together with its

FIG. 4. VERTICAL SPINDLE ELECTRIC CENTRIFUGAL SINKING PUMP (WORTHINGTON).

26ft. suction pipe, and the discharge column with the weight of water therein contained. The capstan is so arranged as to give a speed of 1ft. per minute in the shaft. A small electric winch has also been erected in the same building alongside the capstan, for the purpose of lowering timbers, ladders, discharge pipes, &c.

The pump itself consists of a Worthington two-stage turbine pump, guaranteed to lift 1000 gallons of water per minute against a natural head of 200ft. This pump, together with a vertical 100h.p. 3-phase, 440 volt, 50 period, squirrel cage, induction motor, running at a full-load speed of 960r.p.m., is bolted to the channel iron forming the pump frame.

The motor is provided with an umbrella-shaped top protruding over the sides, which are also totally covered. The object of this is to prevent any moisture getting in, and at the same time to ensure sufficient ventilation. The weight of the motor is taken up with an adjustable ball-thrust bearing, and the limpeler shaft is also taken up on a thrust bearing, the two shaftings being connected by couplings held together with a number of small bolts enclosed in rubber washers. The latter thrust bearing is provided with a water-cooled chamber.

Directly above the pump is a throttle valve which governs the discharge, while immediately above this a check valve supports the weight of water contained in the discharge pipe in case of a stoppage. Before starting, the pump is primed with water from the rising main, and the throttle valve is then closed. This latter valve is then opened slowly so as to build up the load gradually. During the unwatering, the throttle valve was so regulated as to keep the motor running up to its normal working capacity, and in this way it was found that the reading of the ammeter on the feeder panel could be easily adjusted to the desired number of amperes. As will be seen from the illustration, the weight of the combined set is taken up on a specially made flexible steel-wire rope which passes over the pulley on the top of the "sheer-legs," down around a solid wheel fastened to the pump frame, the "dead" end being made fast to a 3in. shafting fixed on the top of the head-gear.

The discharge pipes are 10in. in diameter, and are made of $\frac{3}{16}$in. lap-welded steel, the flanges riveted on. These have been sup-

FIG. 1. GENERAL VIEW OF PLANT FOR COLLECTING DUST FROM SCREENS.

plied in 12ft. lengths, and the joints consist of rubber washers.

As an example of the balancing of the pump, it may be stated that the whole apparatus has been lowered with 200ft. of piping, from suction to discharge, with a couple of men steadying the discharge pipe only.

During unwatering operations the pump requires the attention of one man on each shift. It is interesting to note that a 26ft. suction pipe was used, and provided that the strainer was kept reasonably clean, there was no difficulty in getting the water down to the suction, even when there was a vertical height of 200ft. from suction to discharge.

Colliery Ventilation and Coal Dust Collecting.

CONSIDERABLE interest is now being taken in the removal of the floating coal dust which rises from the screens and tipplers on the pit bank, and apparatus is being used to collect this dust and prevent it being carried down into the mine.

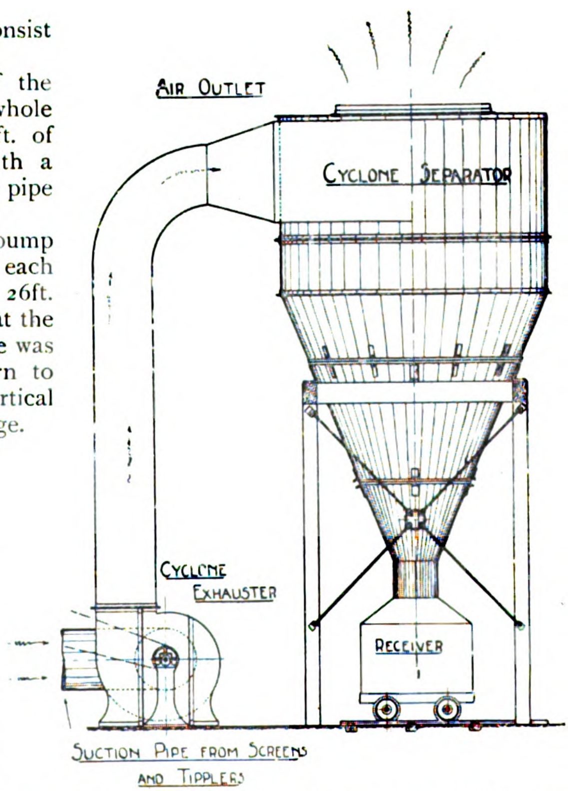


FIG. 2. GENERAL ARRANGEMENT OF DUST-COLLECTING PLANT.

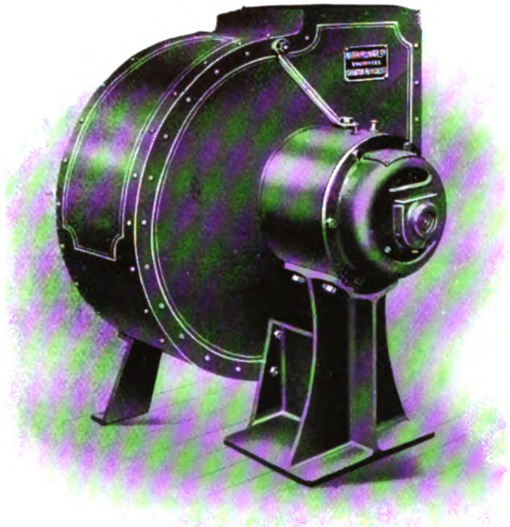


Fig. 3. The Cyclone Electric Exhauster.

Messrs. Matthews & Yates, Ltd., of Cyclone Works, Swinton, Manchester, have carried out some very successful plants for dealing with this fine dust. One of these plants has been installed for Messrs. The Strafford Collieries Company, Ltd. The tipplers and screens, and all points at which dust is made, are provided with large galvanized sheet-steel hoods; these are connected by galvanized sheet-steel trunks to the inlet of a Cyclone exhauster. This is a centrifugal type of fan, which sucks away a large volume of dust-laden air from the hoods, and discharges the mixture of dust and air into a Cyclone separator, which separates the dust from the air, depositing the dust into a pit tub, and the air is allowed to pass out at the top. The exhauster in this particular installation is driven by belt from a steam engine, although of course the system is equally suitable for electric driving. Fig. 1 shows the general arrangement of this plant. The separator is supported on a square timber framework, and the exhauster and its engine are situated in the shed adjoining this. The main suction trunk from the screens, &c., can be seen passing out on the right. Fig. 2 is an outline drawing of the plant showing the general arrangement of the exhauster, main air-duct and separator; it gives a good idea of the proportions of this part of the Cyclone separator and the several parts of the equipment.

The plant has now been working for some months and is giving very satisfactory results. The advantages claimed for this valuable introduction are:—

That the danger of the dust being drawn down the shaft is reduced to a minimum; cleaner and healthier atmosphere for the workers is secured; less trouble is experi-

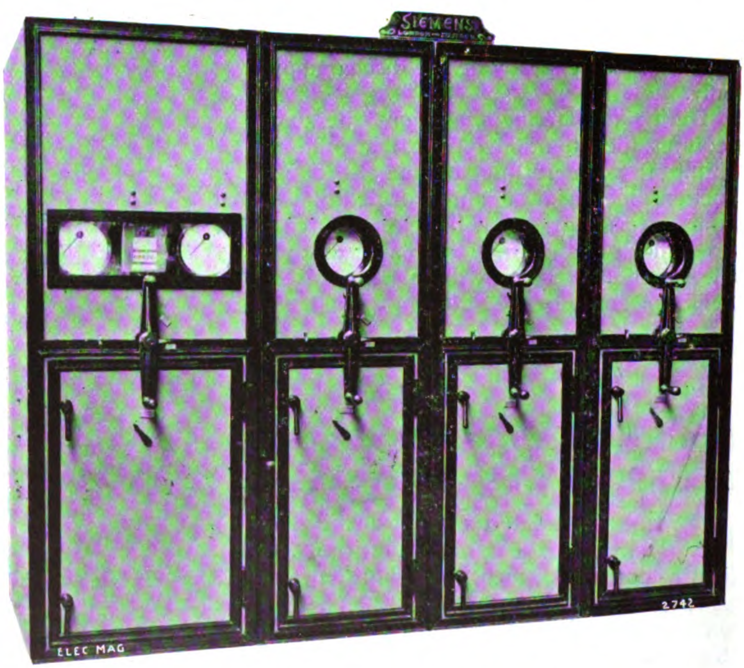


Fig. 1. Siemens High-tension Mining Switchboard.

enced with belts and bearings, which are always liable to be affected by the presence of floating dust in the air; there is a ready sale for the dust which is collected, and there is no doubt that in a very few years' time all those collieries in which the screens are close to the shaft will be equipped with some plant of this description.

The Cyclone electric blower or exhauster is shown in Fig. 3; it is a steel-plate fan combined with an electric motor, being used extensively for ventilating sinkings, &c., and when fitted with a more powerful motor to enable the fan to run at a higher speed, it is suitable for dust-collecting or similar work.

High-tension Mining Switchgear.

THE illustrations Figs. 1 and 2 are of a high-tension mining switchboard and exciter pillar respectively, which have been supplied recently by Messrs. Siemens Bros. Dynamo Works, Ltd., for the generating station of a colliery in South Wales.

The switchboard shown is built up of a number of the firm's standard mining pillars, and is designed for dealing with single-phase current at 2500 volts, 40 periods. As will be seen from the illustration there are four pillars; the one on the left-hand side is for controlling a 150kw. single-phase alternator, the next is for a 30amp. feeder, while the two pillars on the right-hand side control two 20amp. feeders.

The 150kw. alternator pillar of the switchboard is equipped with:—

1 ammeter.
1 voltmeter.
1 watt-hour meter.
1 current transformer.
1 potential transformer.
2 fuses for protecting the above.
1 double-pole automatic oil switch.
1 double-pole isolating switch.

Each feeder pillar is equipped with the following apparatus:

1 ammeter.
1 double-pole automatic oil switch.
1 double-pole isolating switch.

The instruments on the generator pillar are operated from the low-tension side of the current and potential transformers, while the ammeters on the feeder pillars are mounted on insulators and directly connected in the high-tension circuit. These mining pillars are built entirely of iron, are fully enclosed, have no combustible parts, and are fitted with a single handle which operates both main and isolating switches, and is interlocked with the door in such a way that the switches cannot be operated in the wrong order, and all accessible parts are made dead before the door can be opened.

The instruments are placed inside the pillar behind a thick plate-glass window, and are thus protected from dust, damp, fire and accidental blows, another advantage being that a plain glass and iron front gives a much

Fig. 2. Exciter Switch Pillar.

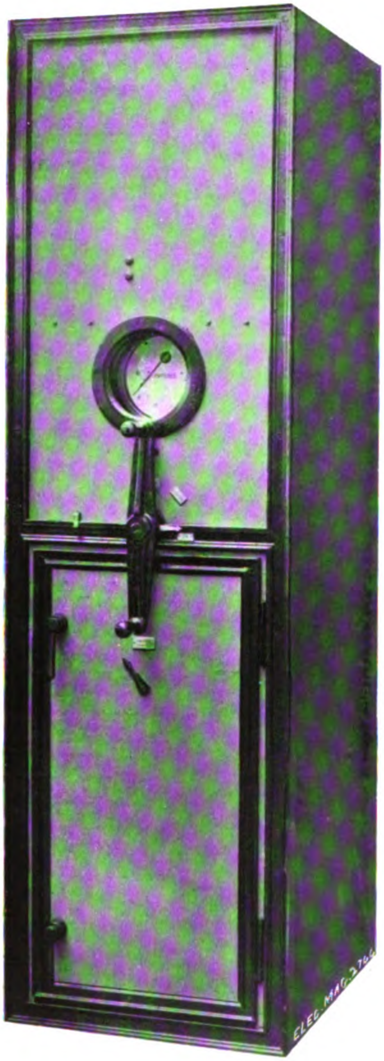


FIG. 3. HIGH-TENSION MOTOR CONTROL PILLAR.

greater feeling of security to an unskilled operator than an array of instruments which he may imagine are carrying high-tension current.

In addition to the switchboard, the switchgear of the generating station also includes an exciter pillar (see Fig. 2), which is located near to the alternator. It is fitted with an ammeter, voltmeter, single-pole field discharge switch and resistance, a shunt rheostat operated by the small hand-wheel, and a series rheostat worked by the large hand-wheel.

The third illustration shows a single-standard high-tension motor control pillar, with superior finish, such as is required for central power stations. However, where a special finish is not required, as, for instance, for general mining work, &c., the pillars are supplied with a somewhat rougher outside finish, but the quality and workmanship of the switchgear itself is of the same high grade as included in the more highly finished pillars.

These pillars are supplied for voltages up to 6000 volts, and currents up to 400amp., and with any desired combination of instruments; for instance, the small pillar shown in the illustration Fig. 3 is equipped with ammeter, oil switch and isolating switch. Trifurcating boxes or cable bushes are supplied on pillars which stand alone to take incoming and outgoing leads.

A considerable number of these pillars have been supplied to the North of England and Wales, and a large number are now on order and in the process of manufacture at the firm's Stafford works.

Water-tube Boilers in Mines.

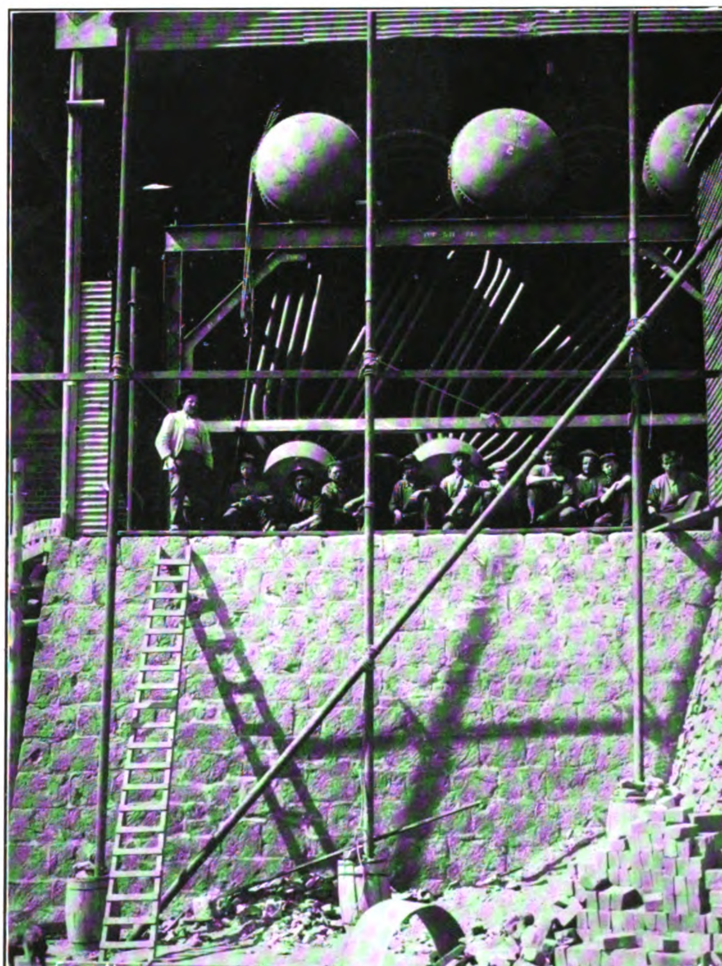
IN these days of severe competition it is necessary in all manufactories to practise the severest economy so as to minimise

FIG. 1. STIRLING BOILER FOR WOOD FUEL CONSUMPTION, QUEENSLAND.

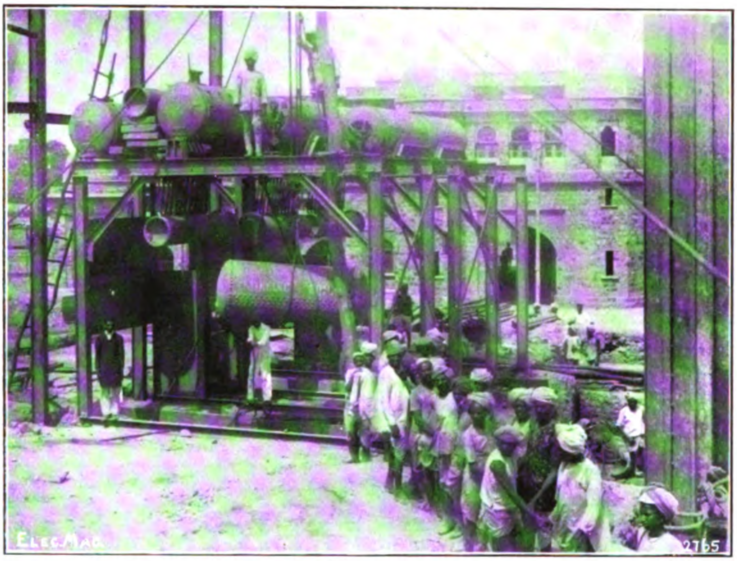
as much as possible the cost of production. In the mining world, in the majority of cases, steam is the power utilised, and as not only is it important that economy should be practised from the point of view of cost, but that, in many parts of the world where mines are worked, fuel is scarce and difficult to get, it is most important that boilers of the most efficient type should be adopted.

The water-tube boiler has proved itself, after long experience, to be much more economical in fuel than boilers of the fire-tube or cylindrical type. Amongst water-tube boilers the well-known Stirling type holds a prominent position, and is very largely used throughout the world in the various mining industries. Practice shows that it gives excellent results when fired with any class of coal from what is practically rubbish to the best coal procurable. Further, it can be readily adapted for any other class of fuel, such as waste heat from coke ovens, gas, oil, wood, peat, &c. When fired by wood a larger grate area is supplied, with increased air space, special wood-firing doors being fitted.

In mines in many parts of America, Australia, &c., the Stirling boiler is giving most satisfactory results fired with wood fuel; the repeat orders which have been received from such mines emphasising the success of the boiler under these conditions. It is well known that peat has a very low calorific value as compared with coal, and it will be of interest to quote here some particulars of a test run on a Stirling boiler when fired with this class of fuel. The boiler in this case was fitted with an ordinary grate for hand firing, and no special preparations were made for the test; the peat was fed through the ordinary coal-firing doors, and consequently there was a large amount of cold air rushing in every time the doors were opened, which naturally occurred very frequently, and it would appear therefore that even better results would be obtained were the boiler fitted with a special grate having a proper feeding device. It is also to be noted that the boiler had not been cleaned for a year previous to the test. The results of the test were as follows:—



Stirling Water-tube Boilers at the Kalgurli Gold Mines.



NATIVE LABOUR ERECTING STIRLING BOILERS IN INDIA.

Date of test	July 5, 1905
Duration of test	4 hours
Heating surface of boiler	1710 sq. ft.
,, ,, of superheater (working flooded)	165 sq. ft.
Heating surface combined	1875 sq. ft.
Grate area	37 sq. ft.
Form of furnace	hand-fired
Class of fuel	Irish peat
Calorific value of fuel	6800b.t.u.
Fuel: Weight of fuel per sq. ft. of grate per hour	37lb.
Total weight of fuel per hour	1369lb.
Percentage of moisture in fuel	17.4 per cent.
Damper	Full open
Total weight of water per hour ...	5425lb.
Actual evaporation per sq. ft. H.S. ...	2.89lb.
,, ,, per lb. of fuel ...	3.96lb.
Total water evaporated from and at 212deg. F. per hour	6526lb.
Evaporation from and at 212deg. F. per sq. ft. heating surface ...	3.48lb.
Evaporation from and at 212deg. F. per lb. of fuel	4.76lb.
Average flue temperature	512deg. F.
Average flue draught	.24in.
Average temperature of feed water	62deg. F.
Average boiler pressure per sq. in.	148lb.
Combustion	Smokeless
Total ingoing b.t.u. per hour. ...	9,309,200
,, outgoing ,, ,, ,, ...	6,310,369
Boiler efficiency	67.6 per cent.
Factor of evaporation	1.203
Total weight of peat for four hours	5475lb.
,, ,, of water for ,, ,,	21700lb.

Besides being in use at many collieries in this country, the Stirling boiler has been very largely adopted in mining plants abroad; amongst the more important of the Colonial installations may be mentioned:

The Hannans Central Syndicate, Kalgurli Gold Fields, Western Australia.

The Kalgurli Gold Mines, Western Australia.

The Smithfield and Phœnix Golden Pile Mining Company, Ltd., Gympie, Queensland.

The Mount Molloy Copper Company, Ltd., North Queensland.

The Blayney Copper Mines and Smelting Company, Ltd., Blayney, New South Wales.

The Gillies Sulphide Concentrating Machine Company, Ltd., Broken Hill, New South Wales.

The Broken Hill Proprietary, Ltd., New South Wales.

The Virginia Gold Mining Company, Bendigo, Victoria.

Knights Deep, South Africa.

Over and above the question of fuel economy in operation, the cost of transhipping a cylindrical boiler both by sea and by land is heavy as compared with that of the water-tube boiler. As already mentioned, many of the mines are situated in out-of-the-way and more or less inaccessible parts of the globe, and where the roads leading to the site of installation are none of the best; it is, therefore, a distinct advantage to adopt a boiler such as the Stirling, which is made and shipped in sections, the heaviest part of which, in the very largest sizes, never exceeds two tons in weight. Although the boiler has to be finally erected on site, and in many cases with but indifferent labour, this erection is a simple operation, and is often done entirely by natives. An example of such erection is illustrated on this page in the photograph of the Stirling boilers under erection for the Delhi tramways.

THE ELECTRICAL EQUIPMENT OF THE FERNDALE COLLIERIES.

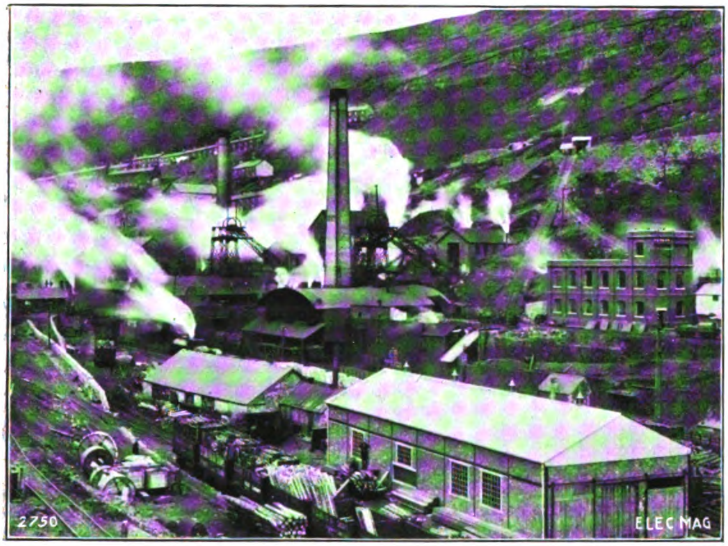


FIG. 1. NOS. 1 AND 5 PITS, FERNDALE COLLIERIES.

THE equipment of an unusually extensive private plant has been in quiet progress for some time past in one of the Rhondda Valleys about twenty miles north of Cardiff, whence comes the noted "Ferndale" small coal.

Messrs. D. Davis & Sons have at present nine pits, one of which has only just been sunk. The other eight have been at work, some of them, for upwards of forty years, and they are now turning out about $1\frac{3}{4}$ million tons of coal per annum.

Messrs. Davis, having determined on the adoption of electricity for their working, began by having proper plans made for a comprehensive scheme along the lines of which development should take place.

The first instalment of plant consisted of several haulages, pumps, and an electrically-driven fan. Current for these was taken from the mains of the South Wales Power Distribution Company; consequently a three-phase, twenty-five cycle system had to be adopted.

Further haulages, pumps, &c., were added from time to time, while Messrs. Davis built

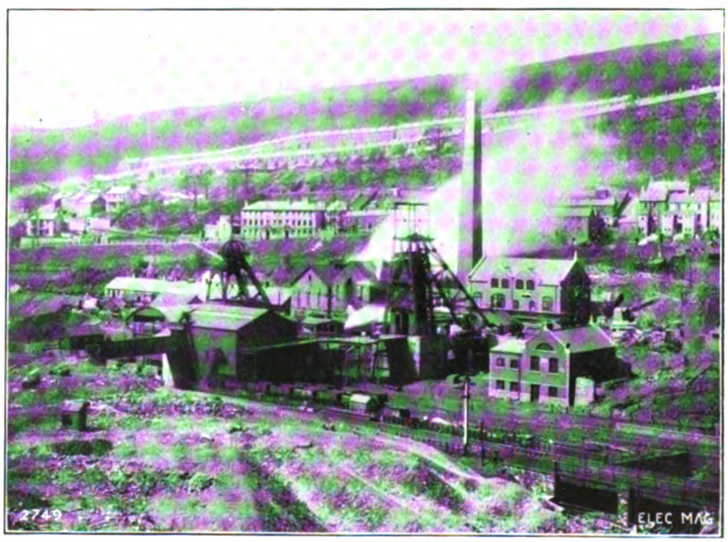


FIG. 2. NOS. 8 AND 9 PITS, FERNDALE COLLIERIES.

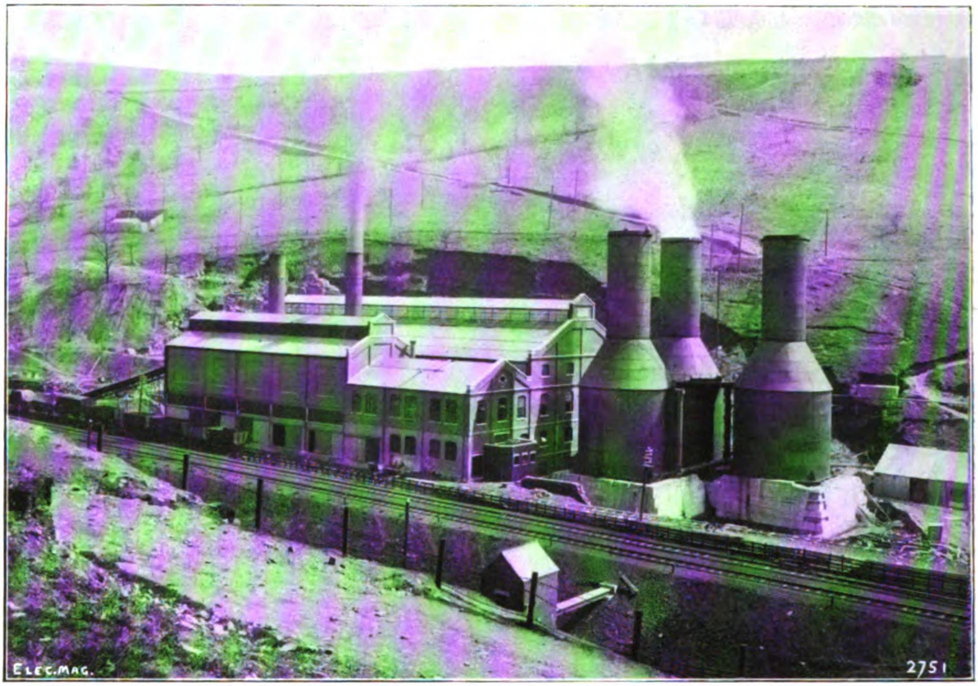


FIG. 3. GENERAL VIEW OF ELECTRIC POWER STATION, FERNDALE COLLIERIES.

their own power station. This policy enabled the power station to be started this spring on a substantial load. At the present time motors aggregating about 3000h.p. are connected and the output of the power station is at the rate of six million units per annum.

Power Generating Station.

The power station at Tylorstown, as will be gathered from the drawings and photographs reproduced in Figs. 3, 4, 5 and 6, is essentially modern in its general arrangement and equipment.

The building is constructed on a steel frame which sustains the whole weight of the roof and upper floors; the brickwork therefore merely serves to clothe the skeleton, This type of building was adopted on account of the ever-present possibility of subsidence at the surface of a colliery. The engine-room walls are faced with glazed brick, and the floor is finished with red tiles. The north end of the building is temporary, in view of future extensions.

The overhead travelling crane is of Messrs. Herbert Morris & Bastert's manufacture, and constructed for dealing with 25 tons, the span being 62ft. 5in. The speeds are as follows:—

Hoisting speeds when fully loaded	12ft.	per minute.
Crab traverse speed ...	80	,, ,,
Crane travel	130	,, ,,

Four water-tube boilers of the three-drum type are installed, made by the Stirling Boiler Company, each having 6209 square feet of heating surface. Each boiler is provided with two underfeed mechanical stokers, and a superheater of the McPhail type with 800 square feet heating surface, and is capable of evaporating 30,000lb. water per hour at a pressure of 180lb. per square inch and imparting a superheat of 150deg. F.

The boilers are arranged in two batteries, each battery being connected by a breeched piece to a steel chimney 7ft. in diameter and 75ft. high.

With the underfeed stokers is used a system of forced draught, which is supplied by two Musgrave fans, each being belt-driven from a motor.

The coal used, which is "Ferndale Small," is run into Messrs. D. Davis & Sons' private siding from the Taff Vale Railway, where the wagons are tilted by hydraulic rams which are worked from the boiler feed pumps.

The coal having been tilted into a hopper, it is then carried by a motor-driven inclined band conveyor into and along the boiler room, where by means of a throw-off carriage the coal is discharged into the bunkers above the boilers, which have a capacity of 150 tons, and is carried by shoots at the bottom of the bunkers to the stoker hoppers. The conveyor carries twenty tons of coal per hour, and runs almost noiselessly.

The ash from the stokers is removed by opening a sluice valve under the boilers, when the ash falls into narrow gauge trucks in the boiler room basement.

The water supply is pumped from Messrs. D. Davis & Sons' No. 8 pit, close by, and is stored in large cast-iron tanks outside the building. There is also storage in a large tank 100ft. long under the boilers.

The feed pumps, of which there are three, are of Messrs. Clarke, Chapman's make, being tandem-compound type, each capable of delivering 5000 gallons of water per hour against the boiler pressure.

The exhaust steam from the pumps is taken to a Cochrane open-type exhaust steam heater, where it heats the feed water on the suction side of the pumps.

For use in emergency there is provided a Worthington tank pump, which draws from the river in the unlikely event of water from the mine failing.

Generating Sets.

The three main steam engines are of the cross-compound type, made by Messrs. Sulzer Bros., each capable of giving 2500b.h.p. at normal load. The dimensions of the cylinders are, high-pressure $33\frac{1}{2}$in. diameter, low-pressure 56in. diameter, stroke 55in., speed 94r.p.m., working pressure 170lb. per square inch with superheat of 150deg. F. at the stop valve. Each engine is supplied with two jet condensers and feed heaters. The injection water is taken from cooling tower concrete tanks through a 4ft. diameter main buried in the engine basement floor, and after passing through the condensers is collected in a wrought-steel hot-well main. The circulating water is lifted to the cooling towers by centrifugal pumps, connected to the hot-well. There are three natural draught wrought-iron cooling towers 33ft. diam. and

Fig. 4. Stirling Boilers at the Ferndale Collieries Electric Power Station.

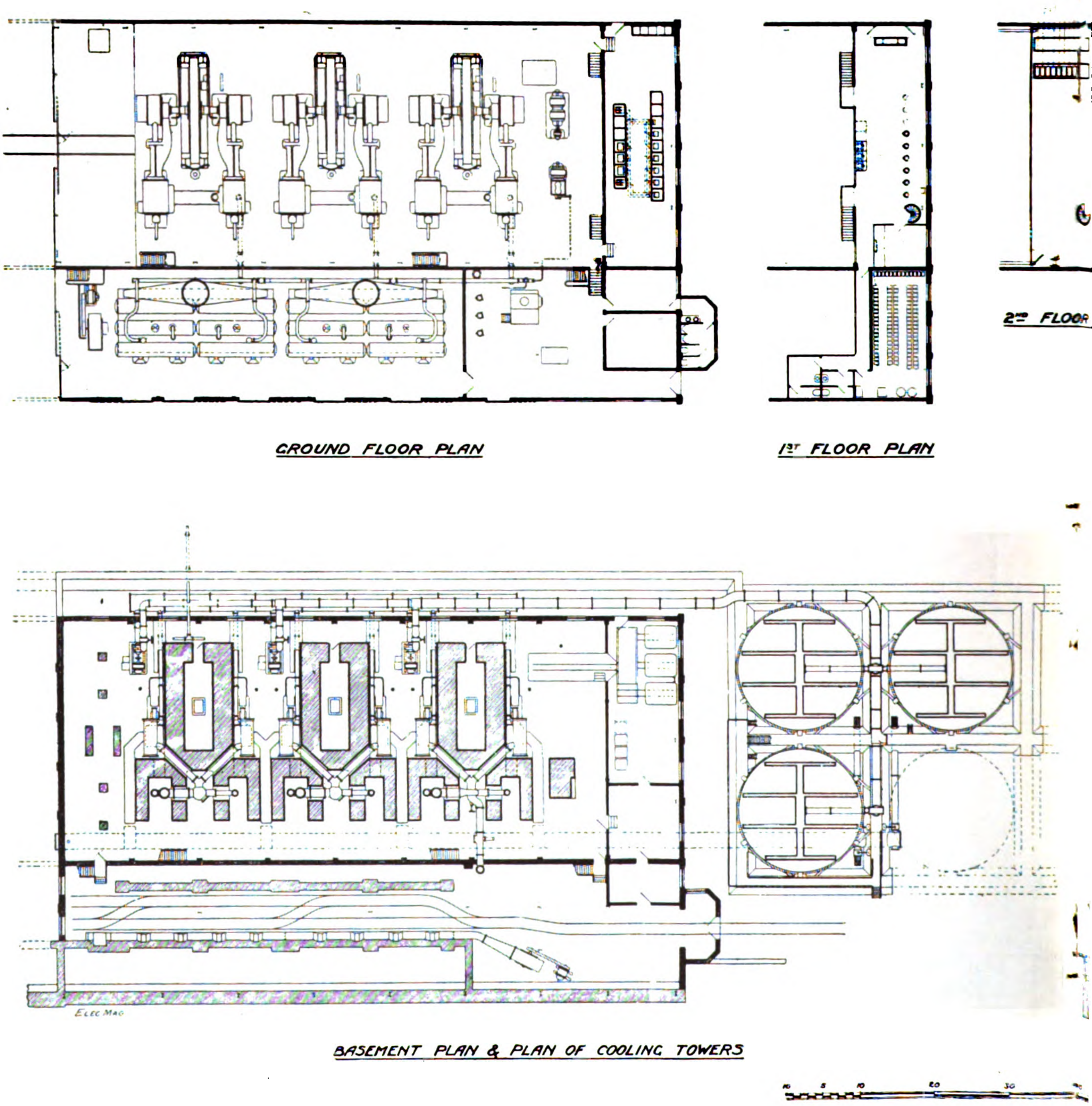
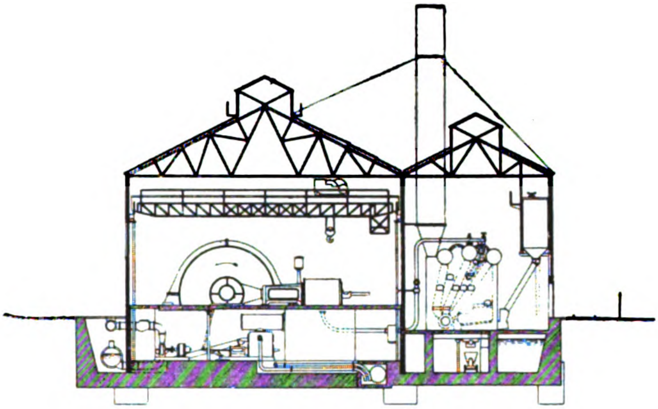
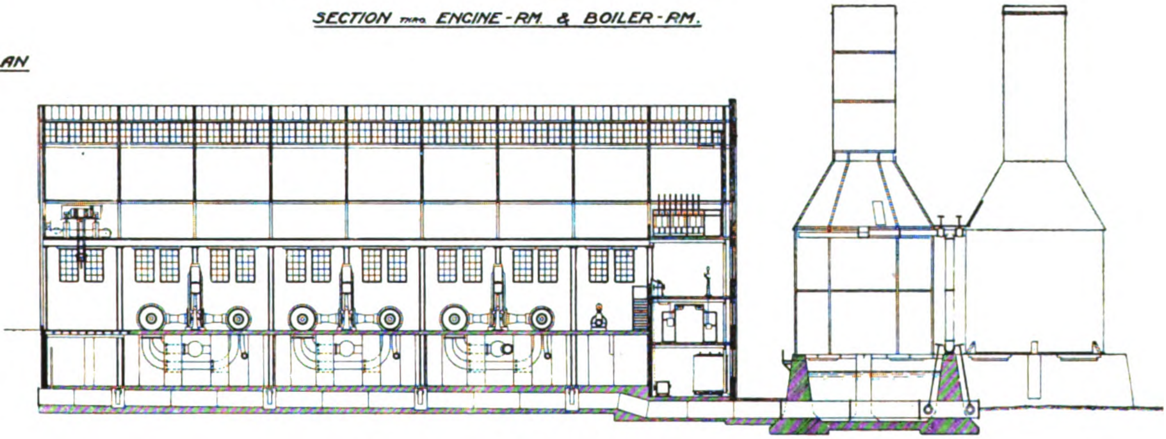


FIG. 5. DETAILS OF THE ELECTRIC POWER GENE

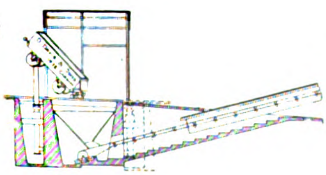


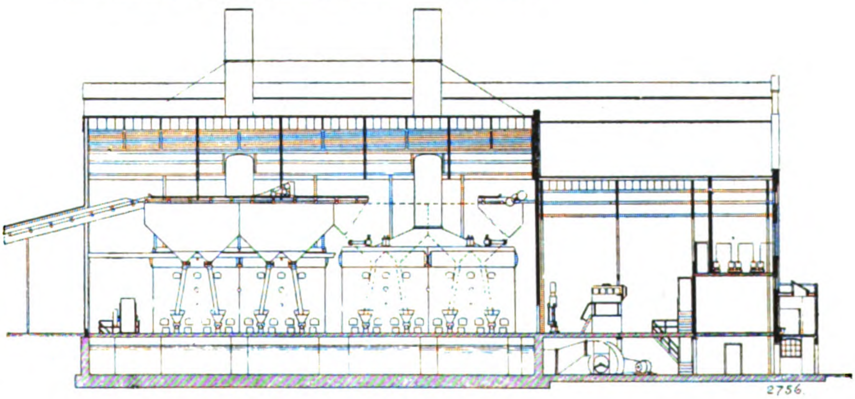
SECTION THRO. ENGINE-RM. & BOILER-RM.

...R PLAN



SECTION THRO. ENGINE-RM. & COOLING TOWERS.





SECTION THRO. CONVEYOR, BOILER-RM., PUMP-RM. &c.

40 50 60 70 80 FEET

...RATING STATION OF THE FERNDALE COLLIERIES.

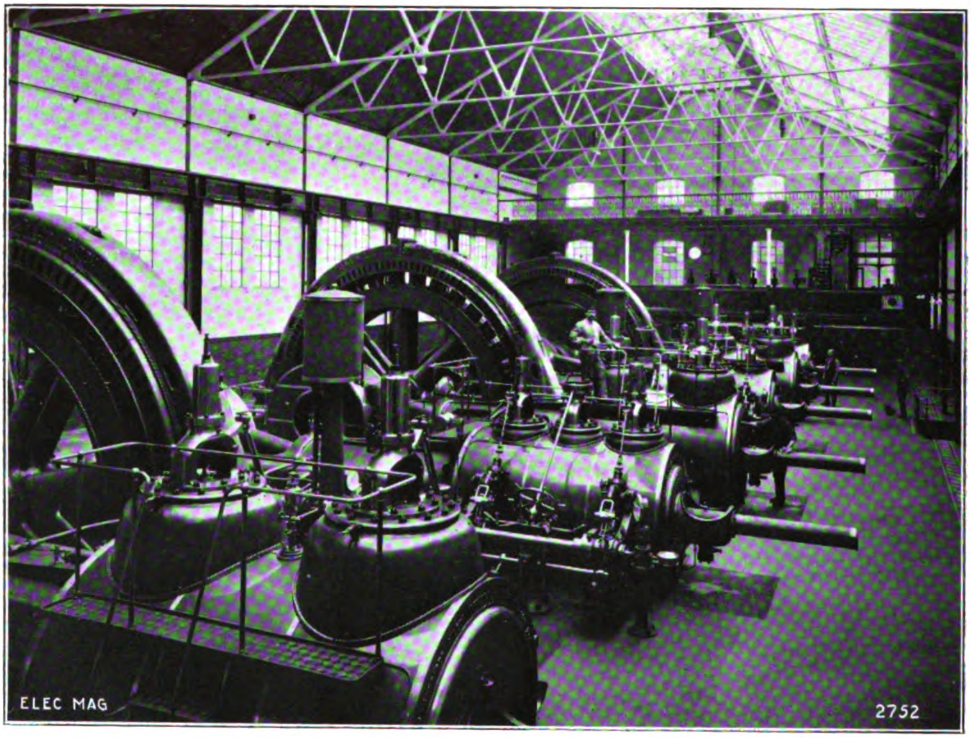


FIG. 6. SULZER-LAHMEYER GENERATORS, ELECTRIC POWER STATION, FERNDALE COLLIERIES.

83ft. high. The circulating water enters about 30ft. from base, and is discharged into wooden troughs, which equally divide the water on cross timbers beneath, and so break it up into a fine rain; after cooling, the water is collected in the concrete tanks under the towers.

The three-phase generators coupled direct to the Sulzer engines are of the revolving fly-wheel type, each having a normal continuous output of 1600kw. at a power-factor of 0.85 and a tension of 2200 volts, and having an overload capacity of 20 per cent. for two hours, or 30 per cent. for half an hour. Guaranteed temperature rise not to exceed 45deg. C. after 10 hours full-load run as measured by thermometer. These generators are of Messrs. The Lahmeyer Electrical Company's make.

The total weight of each generator is 107 tons, that of the revolving field being approximately 75 tons. The generators are separately excited at 200 volts from a 75kw. Belliss-Lahmeyer exciter, running at a speed of 525r.p.m.

As spare to the Belliss exciter there is a 100-120kw. motor generator booster set consisting of a 180b.h.p. 2200-volt three-phase motor, coupled to a shunt-wound 120kw. generator. The booster is mounted at the end of the shaft and is capable of raising the voltage from 200 to 290 volts to charge the storage battery; the latter has a capacity of 380 ampere hours when discharging at a 38 ampere rate, and consists of 115 cells. The regulation is done by hand by a 21-contact regulating switch. The battery can also be charged by the Belliss set, the generator of which is so arranged that its voltage can be increased to 290 volts in order to allow its acting as a spare in case of a breakdown in the motor generator set.

Power House Switch Gear.

The electric current is taken from the generators to the main switchboard, which is situated at the south end of the building and is of the most modern type. The operating platform is occupied by a series of desks from which the main generators are controlled, and switch pillars controlling the feeders. These desks and pillars merely

carry switch handles and low tension instruments. The actual switches themselves are enclosed on a lower storey. This has the advantage of giving ample room for the disposition of the high-tension gear in a chamber which need only be visited for the purpose of inspection, and leaves the switchboard operators free to attend to their duties on the platform, which is even safer than a switchboard of an ordinary low-tension station. These switches have been provided with Ferranti time limit relays.

The current is taken from the power station by main feeders to distributing centres at the various pits. The motors are generally worked at 2200 volts, but in certain places, in accordance with the Home Office Rules, the current has to be stepped down by transformers to 440 volts.

Nos. 8 and 9 pits, the latter being a new one, are close to the power station. Current is taken to them by underground cables at a pressure of 2200 volts, the basement of the new fan house serving as a convenient distributing station.

Nos. 6 and 7 pits are some 900 yards from the power station. Current also at 2200 volts is taken to them by overhead wires to a distributing station containing switchboards, which, in accordance with the Home Office Regulations, control the various feeders for the shafts and surface workings.

In the case of Nos. 1 and 5 pits at Ferndale, which are about 2500 yards away from the power station, and Nos. 2 and 4 pits, which are some 2000 yards still further up the valley, the current is stepped up by oil-cooled transformers to 6600 volts, and transmitted by bare overhead wires which are run on duplicate poles. Step-down transformers are fixed at sub-stations convenient to the pits where the pressure is again reduced to 2200 volts or 440 volts as required.

Through the village of Ferndale it was impossible to use overhead wires; underground cables therefore had to be laid. These are of the usual armour-covered, paper-insulated, three-core type.

In addition to the transmission lines, a complete scheme of telephones has been laid down, by which communication between the various switch houses and the power station is effected.

Haulage Plants.

Some twenty-two haulages are being installed, varying in size from 200h.p. to 50h.p. The gears were made specially heavy to Mr. W. H. Patchell's specification by the Uskside Engineering Company. Slow-speed motors have generally been adopted, and the electrical equipment is of massive construction, supplied by the Lahmeyer Company; the controllers are of a new design arranged by the consulting engineer. The special attention paid to the designing of the controllers has led to an absolute freedom from the troubles which have been commonly complained of at other places.

The haulages are generally of the main-and-tail type, and work at a speed of six miles an hour. They are principally of single reduction, but in some cases, to suit the exigencies of the positions in which they had to be installed, the double-reduction type has been chosen. In all cases there is a flexible coupling between the motor and the gearing,

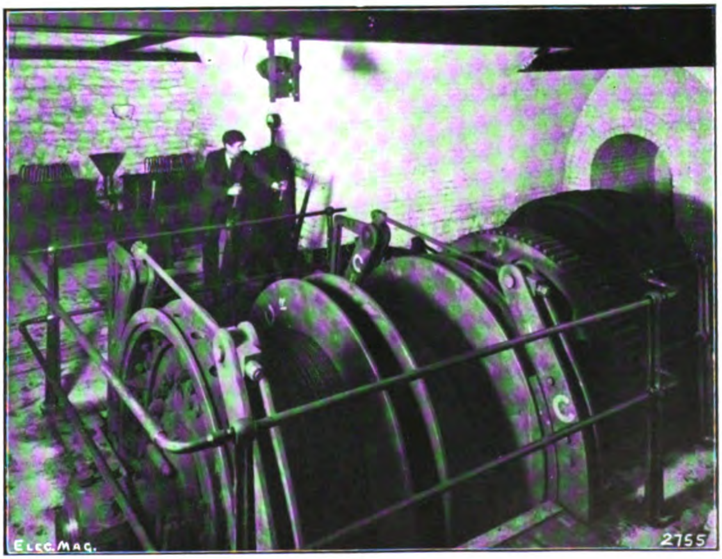


FIG. 7. 200H.P. HAULAGE GEAR IN NO. 1 PIT, FERNDALE COLLIERIES.

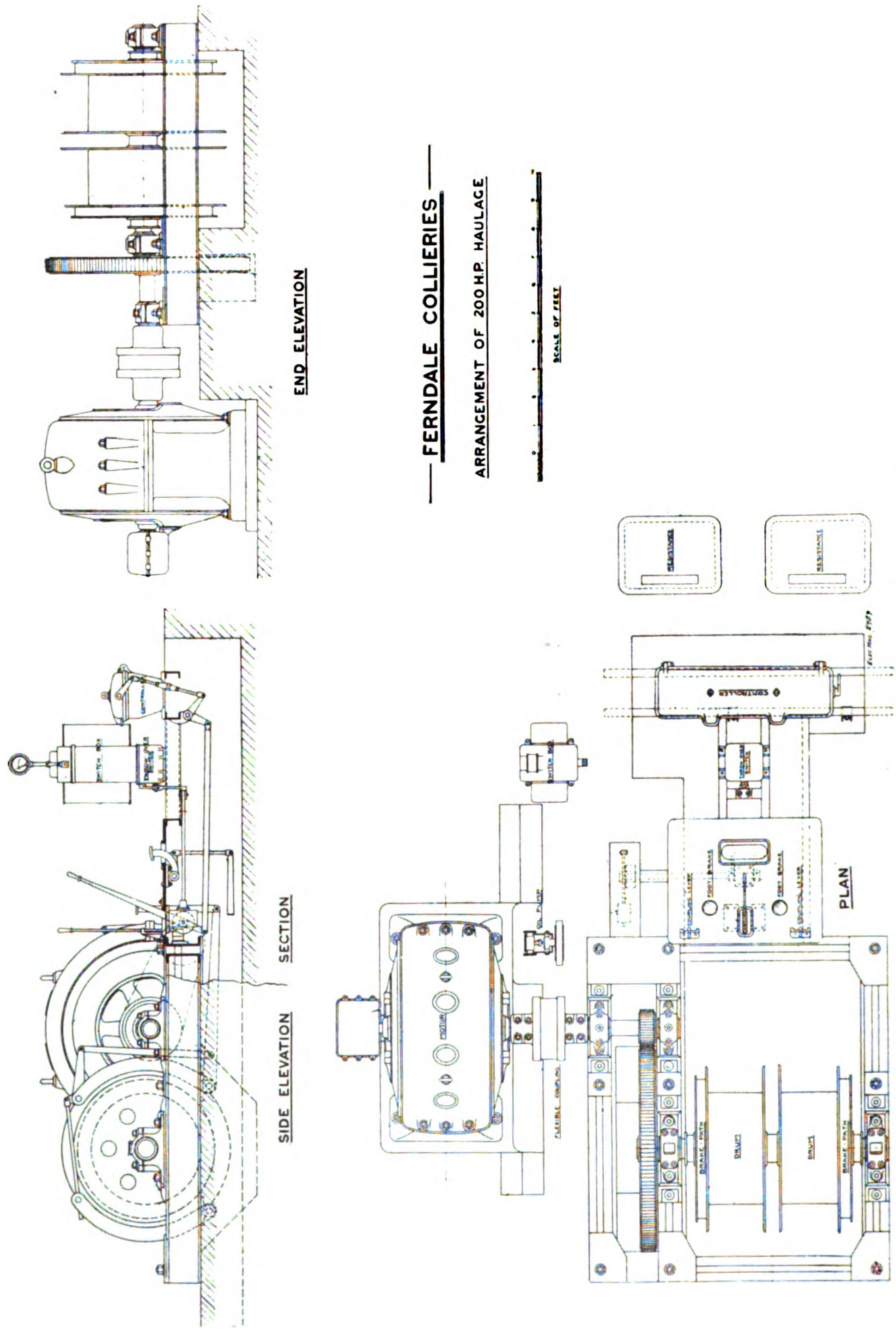


FIG. 8. DETAILS OF THE 200H.P. HAULAGE GEAR SHOWN IN FIG. 7.

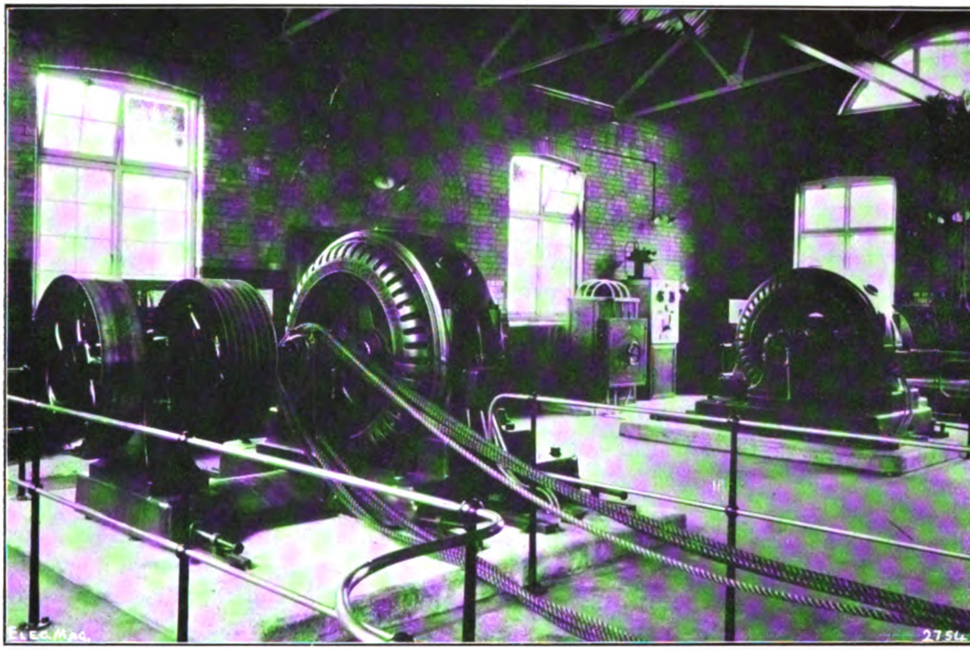


Fig. 9 Motors of Electrically-driven Fans, No. 9 Pit, Ferndale Collieries.

which to a very large extent takes the jar of the gear off the motor. These electrically-driven gears are very popular with the drivers; and owing to their reliability and ease of working, not only have great economies been effected over the old steam-driven haulage gears, but it has also been possible to obtain a greatly increased output, as there are no delays in starting up; the haulage gear commences work immediately the driver manipulates the lever.

Pumping.

The underground pumping is now being handled electrically, in some cases by three-throw pumps made by the Uskside Company, and in other cases by high-lift Sulzer centrifugal pumps.

Ventilation.

This is a most important part of the work, not only from the colliery manager's point of view, but also inasmuch as the continuous use of the fans makes a most desirable load for the power station

At the new pit a "Sirocco" fan has been put down to handle 300,000 cubic feet of air per minute at a 4in. water gauge. This fan is driven electrically from either end of its shaft by two Lahmeyer motors working at 2200 volts. One of the "Schiele" fans, which has been driven for several years by a steam engine, and doing 300,000 cubic feet of air per minute at 3.5in. water gauge, has lately been converted to an electrical drive.

Two further "Sirocco" fans are at present being installed, each capable of doing 125,000 cubic feet of air per minute at 4in. water gauge.

Electric Winding.

The new pit is being entirely equipped with electrical machinery, including a winder, which is being manufactured by the Lahmeyer Electrical Company. It will work on what is known as the "Ilgner" system, and is constructed to raise 1800 tons of coal a day.

The consulting engineer, Mr. W. H. Patchell, M.Inst.C.E., M.I.E.E., of Caxton House, Westminster, has for many years been largely identified with the introduction of electricity for mines, and was the electrical member of the Home Office Departmental Committee for the drafting of suitable rules for the use of electricity in mines. He has collaborated throughout with Mr. David Hannah, who holds the responsible position of manager to the Ferndale Collieries, and to whom in a great measure credit for the success of the Ferndale installation is due.

PUMPING PLANT
at the
HARTON AND WHITBURN PITS OF THE HARTON COAL COMPANY.

As is generally known, pumps of the high-lift centrifugal type are so suitable for mining and similar duty that their universal adoption for all work of this class can only be a matter of time. Their compactness and suitability for direct-coupling to high-speed electric motors, their uniform delivery and smooth running, as well as their high efficiency and great flexibility of operation, are but a few of the points which those interested in mining cannot fail to appreciate.

Among those who were quick to see the advantages possessed by plant of this kind was the Harton Coal Company, of South Shields, and the plant they have recently put down, upon the advice of their consulting engineer, Mr. Maurice Georgi, forms a noteworthy example of the advance which has been made within recent years in this branch of engineering.

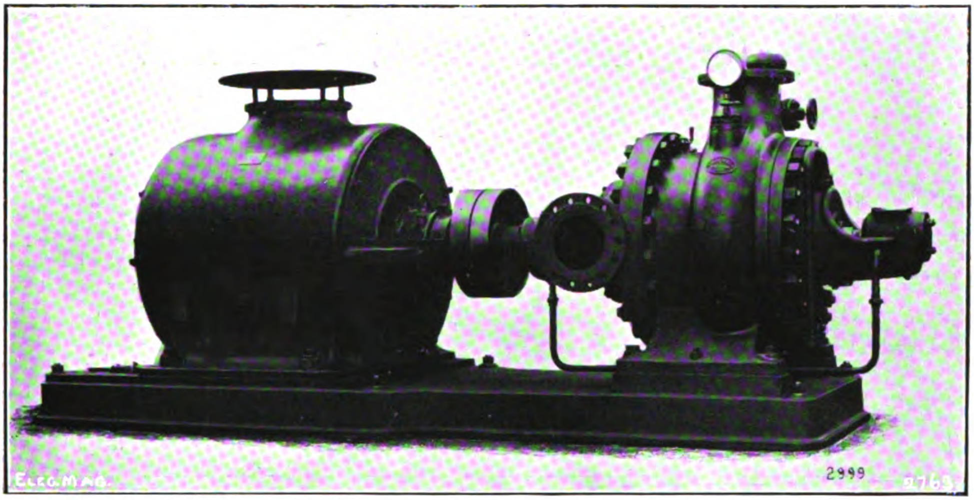
Two sets have been installed, one at the Harton Pit and one at the Whitburn Pit, while a third set is on order for the latter. The pumps are of the Sulzer four stage type, and are driven by Brown-Boveri motors rated at 650h.p., and running at the high speed of 2350r.p.m.

The set at Harton delivers normally 1000 gallons of water per minute against a head of 1345ft., and the brake horse-power required at this duty is 610. The set at Whitburn delivers normally 1000 gallons per minute, against a head of 1180ft., with the power of 540b.h.p. It is of interest to note that while the guaranteed efficiency of these pumps was 71 per cent., on being tested they exceeded this figure by $1\frac{1}{2}$ per cent.

These sets run at a higher speed, and it is believed are also larger than any other pumping plants of the kind working in collieries in Great Britain, and an interesting feature of those at Whitburn is the exceptionally great suction lift of 25ft. under which they have to work, the length of the suction pipe being 140yds.

The accompanying illustration shows one of the plants complete, although it gives but an indifferent idea of the dimensions of the set. The suction nozzle is brought out horizontally at the side of the pump, while the discharge, which is vertical, is on the top of the casing. It will be noticed also that the pump casing is all in one piece, thus obviating the necessity for packing between the several chambers. The end castings, one of which carries the outer bearing and the other the inner bearing and suction nozzle, are securely fitted and bolted to the main casing. The bearings, as will be seen from the figure, are situated outside the water chambers on both sides. They are provided with ring lubrication which supplies the bearing surfaces with an ample quantity of oil, an arrangement which has the great advantage of requiring practically no attention, and at the same time being very economical. Inside the pump the pressure is so distributed that there is practically no axial thrust, while a pressure-reducing chamber is arranged between the pressure chamber of the pump and the stuffing boxes on the delivery side. The water flowing from this reducing chamber serves at the same time to cool the bearings.

The impellers and guide wheels which surround them are of a special alloy of bronze, and the shaft, which is of non-corro.



650B.H.P. BROWN-BOVERI MOTOR DRIVING SULZER CENTRIFUGAL PUMP.

sive high-grade nickel steel, is also entirely covered with gun-metal. As the water with which the pumps have to deal is of a bad quality, all parts coming into direct contact with it are made of gun-metal.

As will be seen from the illustration, the pumps are direct-coupled to and mounted on the same bedplate with the motors. The latter are of the three-phase induction type with permanently short-circuited rotors, and are directly connected to the 2700-volt supply which is obtained from the Newcastle-on-Tyne Electric Supply Company's 40-period three-phase system.

The starting is carried out at a reduced pressure by means of suitable transformers of the oil-cooled type, and complete panels with three-phase oil switches and the necessary instruments are provided in the motor rooms. The starting transformers are arranged to give two lower pressures for starting purposes, and a special feature is the use of non-inductive resistances across the contacts of the starting switches, whereby the stator circuit is not interrupted at the successive steps.

The motors are constructed in accordance with Brown, Boveri & Co.'s standard practice in respect to high-speed work, the casings, core-plates, and windings being arranged in such a manner that thorough ventilation is obtained. The cooling air is drawn into the machine along the shaft, in passages provided for the purpose, after which it passes through ducts left in the iron core of both rotor and stator, and finally out by the ventilation chimney on top of the carcase. Specially long bearings, fitted with oil ring lubrication, are provided, and like those of the pumps they are also water-jacketed, an ample supply of water being kept circulating about them. The motors are coupled to the pumps by means of flexible couplings, and are so arranged on the bedplates that they can be drawn back longitudinally from the pumps until the half couplings clear one another, so that the pump or motor can be rotated independently of each other, if required.

As will be seen, the design of the motor is such that its windings, &c., are protected against dripping water, while the non-hygroscopic character of the insulation used renders the windings impervious to damp.

All three motors have each an efficiency of 91 per cent. at full rated load (650b.h.p.).

Two of the sets have been at work since April last, while the third is in course of construction. In every respect the motors and pumps have been most successful in operation, and there can be no doubt that the installations at Harton and Whitburn, unique as they are in respect to size and speed, will prove to be the forerunners of equally large and important plants of a similar type being adopted in other places in the future.

NOTEWORTHY EXHIBITS AT THE RECENT MINING EXHIBITION, OLYMPIA.

Electrical Mining Plant.

As being thoroughly representative of the widespread developments of electrical apparatus for mining service, the exhibit of Ernest Scott & Mountain, Ltd., was exceptionally prominent. Occupying quite a large space there were examples of heavy power plants, including electric generators, winding gears, hauling gears, pumps, &c. The electric generator shown was a three-phase alternating-current machine, having a capacity of 190k.v.a. at 650 volts, 50 periods, when operating at the standard speed of 500r.p.m.

Another noteworthy exhibit was a double-drum electrically-driven winding gear, Fig. 1, designed for lifting an out-of-balance load of one ton from a shaft 500ft. deep at a speed of 350ft. per minute. Each drum is provided with a jaw clutch, so that the level of the cages may be adjusted, and a powerful band brake operated by a foot lever. In addition, a solenoid magnetic brake is provided, so that should the current fail at any time, the brake would come into action and hold the load. Depth indicators are provided for showing the position of the cages in the shaft. The gear is driven by a 40h.p. three-phase alternating-current motor, mounted on the bed-plate and driving through a machine-cut pinion.

Fig. 2 shows a 5-10h.p. portable main-rope haulage gear as exhibited. This gear is fitted with an 18in. by 10in. drum, and is suitable for a rope speed of four miles per hour. The whole of the gearing is machine-cut, and the bearings are of gun-metal, lined throughout, and arranged so that by withdrawing a few bolts they can be lifted out of

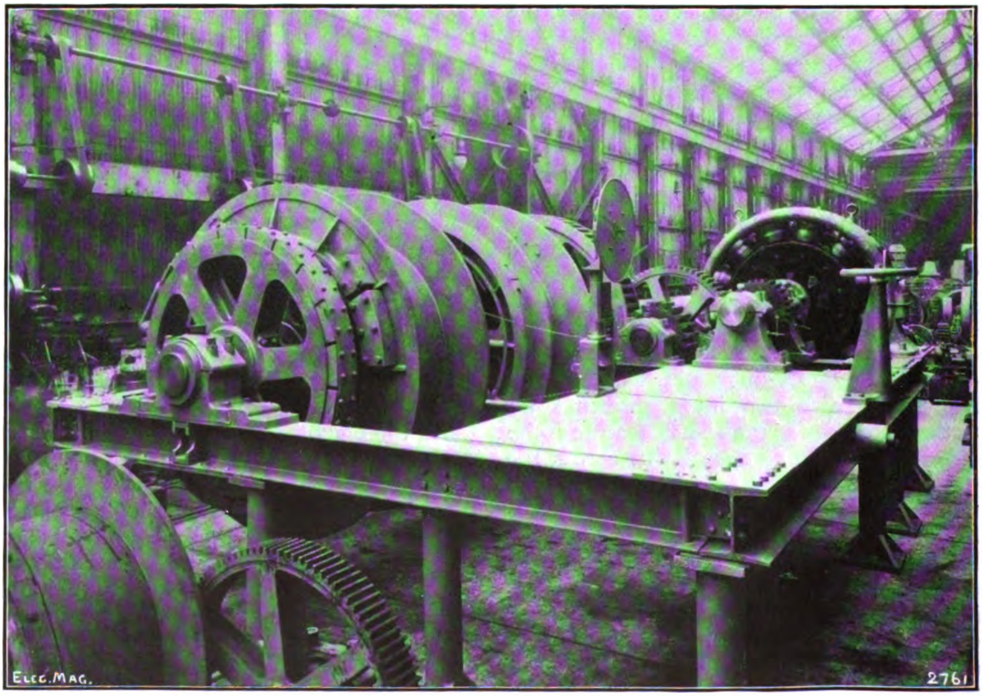


Fig. 1. Scott & Mountain 40h.p. Double Drum Electric Winding Gear.

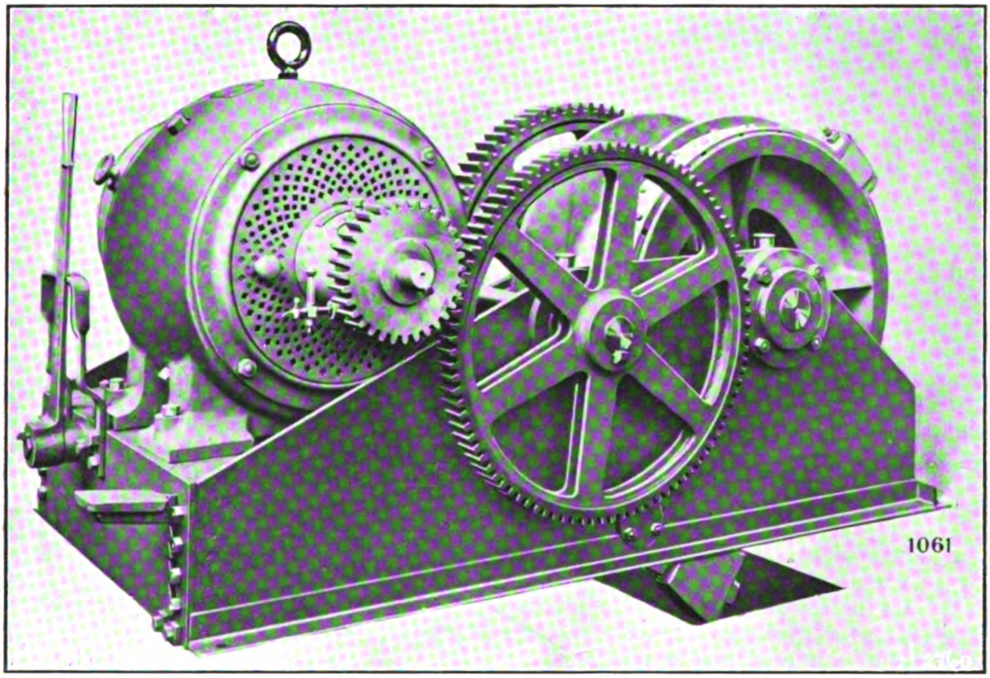


FIG. 2. 5-10H.P. ELECTRIC HAULAGE GEAR.

the frame. The bedplate is of steel, stiffened with angles and tie bars, and bolted together for ease of erection in-bye. A powerful band brake of the all-round type is fitted and operated by a foot lever. The electric motor is mounted on the bedplate, and drives the gear through a rawhide or forged-steel machine-cut pinion. A jaw clutch is provided and operated by a hand lever. The motor of the haulage gear is controlled by a special mining reversing controller with quick make and break on every contact. The contacts are contained in a water-tight case, with a single hand wheel for starting, stopping, and reversing.

A three-throw horizontal mining pump—diameter of rams 4in., length of stroke 5in., and capable of deliver-

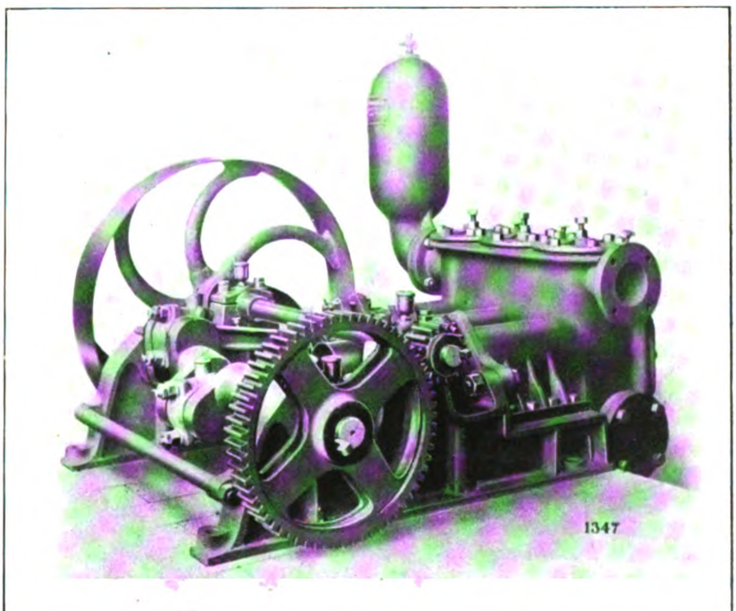


FIG. 3. SCOTT & MOUNTAIN THREE-THROW PUMP

ing twenty-seven gallons of water per minute against a head of 200ft.—was also shown. The electric motor is mounted on the pump bedplate, and drives through a machine-cut raw-hide or forged-steel pinion. The pump and motor can, if desired, be mounted on wheels to facilitate removal from one part of the mine to another.

Of exceptional interest was the vertical electric centrifugal pump shown : the motor and pump are coupled together, and arranged so that the delivery water from the pump passes through a liner round the motor and through a breeches pipe on the top and into the rising main, supported on this breeches plate. The whole weight of the rising main, pump, motor, water column, &c., is taken by wire ropes passing round pulleys on the side of the motor. This arrangement has the following advantages :—

1. The weight of the rising main and water column is supported centrally on the motor, and as the unwatering proceeds it is only necessary to lower the pump down on its ropes and fix additional lengths of piping at the top, thus saving a considerable amount of time in the unwatering operations.
2. The minimum of space is taken up in the shaft owing to the rising main being supported on the pump.
3. It is very easy to handle the rising main, as the ropes lowering the pump can be used as guides.
4. The pump, when the unwatering operations are over, can have brackets put on to the bottom sections, and be permanently fixed on the foundations.

The dimensions and capacity of the pump exhibited are as follows :—

No. of stages	4
Gallons per minute	260
Maximum head in feet ...	300
R.P.M.	1530
Volts	500
Type of motor : shunt wound, variable speed	
Effective h.p.	40

With regard to switchgear this can be arranged so that the pump is controlled from bank, a special three-core cable (*i.e.*, with one small core for carrying the shunt wire) being provided for carrying the current to the pump. If preferred the switchgear can be mounted on the pump motor frame.

Other exhibits included a standard continuous-current motor, 4-pole semi-enclosed type, 800r.p.m., 500-volts, 50e.h.p.; a standard valve box and valve, as fitted to the firm's three-throw 12½in. by 18in. mining pumps ; and standard mining switchboards, constructed to comply with the Home Office rules for the use of electricity in mines.

Bentley's Patent Ball-bearing Conveyor-screen.

One of the most attractive exhibits in the eyes of the mining engineer was provided by the New Lowca Engineering Company, Ltd., of Whitehaven, who showed a noteworthy improved type of screening conveyor. The stand was occupied by a full-sized example of a picking belt for handling coal, and an electrically-driven screen-conveyor; there were also shown various models and full-sized detail parts indicating the methods and materials employed in the construction of the new machines. The screen, which is very suitable for electrical operation, was shown driven by a 5h.p. motor, but the actual power consumed was seen to be not in excess of 1h.p.; the length of the screen being 20ft. by 2ft. it was capable of adequately screening any class of material, and has a capacity for coal at the rate of approximately 20 tons per hour.

There would seem to be no doubt at all that the screen of the future, especially for

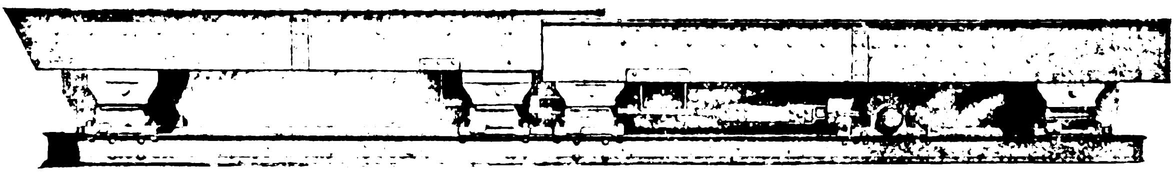


Fig. 1. General view of the Bentley Patent Screen Conveyor, showing arrangement of Drive.

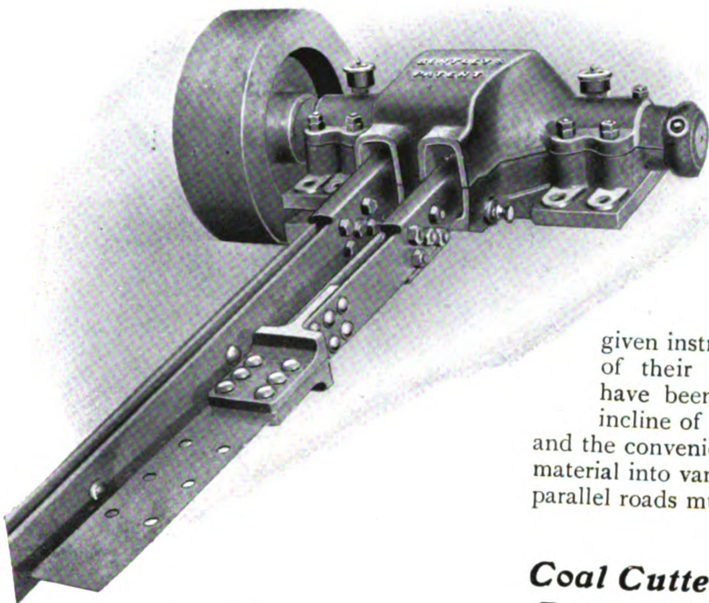


FIG. 2. DUST-PROOF CRANK CASE, COMPLETE.

coal handling, is to be of the horizontal reciprocating type, and designers of this class of machine have had in view the simplicity of lubrication and absence of all wearing parts, joints and other details liable to damage from shock. The simplicity of this new machine of the Lowca Company must appeal even to those who are not particularly interested in colliery working, as the bearings upon which it rests are confined in dust-tight cases, and the crank-shaft and driving-rods are also totally enclosed. It will be seen from the illustrations that the screen is carried on a combination introducing the ball-bearing and the inclined - plane principles. Although this machine has been undergoing test in actual operation dealing with 1000 tons per day for the past two years, it was only in the early part of this year that the company proceeded to place the screens on the market, preferring to thoroughly test the principle before doing so. It is sufficient to know that during this year orders for coal-handling plant, including forty - six machines capable of handling over 10,000 tons per day, have been received, many of these being repeat orders, one colliery company having given instructions for rebuilding three of their pit banks. These screens have been supplied to work up an incline of as much as one in eighteen, and the convenience of being able to screen material into various sizes as it passes over parallel roads must be obvious.

Coal Cutters, Conveyors, &c.

It was only in keeping with the well-known reputation of Messrs. Mavor & Coulson that they should have one of the most pro-

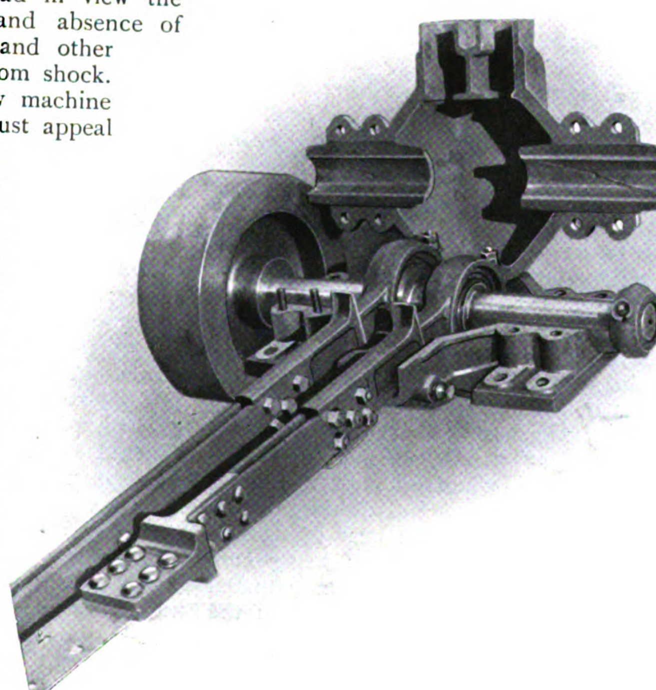


FIG. 3. DUST-PROOF CRANK CASE, OPEN.

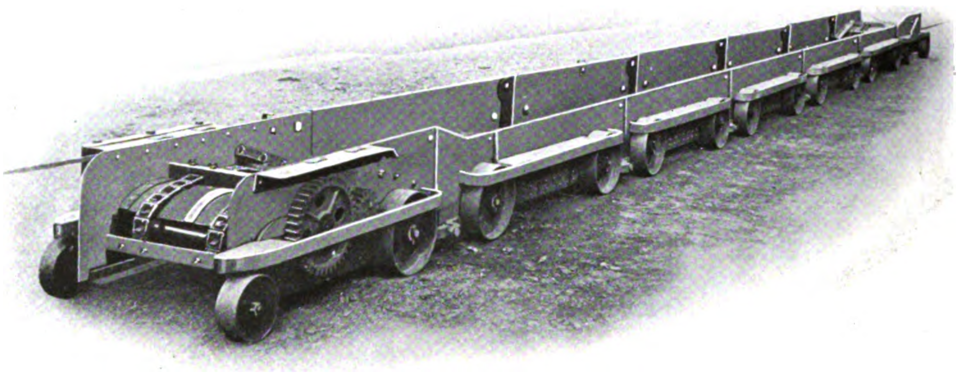


FIG. 1. GIBB COAL CONVEYOR: GENERAL VIEW FROM COAL SIDE.

minent exhibits at the recent Exhibition. Most mining men are familiar with the "Pickquick" type of coal cutter, of which several examples, both of the electric and compressed-air form, were shown. The most interesting apparatus exhibited was a full-size example of a new underground conveyor, the "Gibb" conveyor, which has only lately been put upon the market and which merits a somewhat more detailed description here.

As will be seen from the illustrations, the conveyor consists generally of a long, low carriage built up by a series of small sections of trucks, the series being provided with a mechanical end discharge, operated by a rope from the same power centre which serves to draw the carriage to and fro along the working face. Naturally the dimensions of the carriage are made to suit the thickness of the seam being worked; the one illustrated has a maximum height from the floor of 20in. and an inside width of 24in., and consists of two end sections and five intermediate sections each 6ft. long. The end discharge is effected by scrapers carried on a pair of endless chains which return under the bottom of the carriage. The scraper chains are driven through gear by rope at the discharging end, the rope being connected to a small haulage gear situated at any convenient place distant from the conveyor.

The type of haulage gear usually adopted is shown in Fig. 2. By a ratchet arrangement of the driving wheel of the discharging end the scraper chain can be cut out of action and the carriage drawn to any position on the face by the same haulage gear and as required. The entire framework of the conveyor is built of steel angles and sheets, the several sections being coupled together by a method which allows perfect freedom of movement. The back end of the conveyor is arranged in a similar manner to the discharging end, but in this case only idler sprocket wheels for carrying the scraper chains are necessary. The capacity of the conveyor depends, of course, upon the thickness of the seam being worked. The makers give, for a total head-room of 18in., and for a carriage with an internal width of 20in., a capacity of about $\frac{1}{2}$cwt. per foot run, that is, a carriage consisting of six intermediate sections would have a capacity of 22cwt.; a seam 2ft. 6in. in thickness or more with a corresponding increase in size of conveyor allowing of a capacity of from 50cwt. upwards. A carriage of seven sections allows of eight men being engaged in filling, so that the actual operation of filling is very quickly effected. When the carriage is full the haulage is set in motion and the carriage drawn along the face towards the road at a speed of about 150ft. per minute. When the carriage reaches the "stops" at the roadway with its end overhanging an empty tub, a trigger is automatically operated which puts into operation the discharging gear, and the endless rope haulage, which continues to run, drives the scrapers, and quickly effects the discharge.

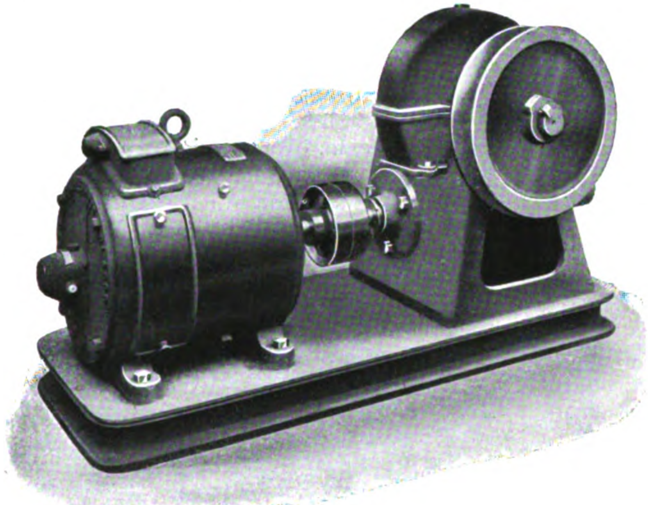


FIG. 2. COAL CONVEYOR HAULAGE GEAR.

The load having been discharged, the direction of travel of the haulage rope is reversed by the electric controller of the haulage gear, the trigger re-engages, locking the discharging gear, and the carriage is returned to the face where the fillers during its absence have been breaking down and preparing the next charge of coal for filling. The moving of the carriage into each new position as the face advances is quite simple. The sections are not disconnected, but the turn pulley of the conveyor haulage rope is moved laterally towards the face and the timbers are so placed as to permit of the carriage being pulled along in a slanting direction until it is thus guided close up to the face into its new working position. It is said that the carriage can be shifted by this method in about twice its own length. The complete operation, including setting props, re-adjusting the haulage pulleys and rope, occupies four men for two or three hours. It is to be noted that this method of following the work forward entails very little disturbance of the timbering. The haulage set operating the conveyor, as illustrated in Fig. 2, is a compact and easily portable machine. Either a compressed-air or an electric machine may be used. The electric type consists either of a direct-current or three-phase motor driving the rope pulley through an oil-immersed worm gear. The motor is controlled by a tramway reversing type controller.

Diamond Coal Cutters.

THE Diamond Coal-cutter Company, of Stennard Works, Wakefield, exhibited a number of their well-known diamond longwall machines, both of the disc and chain types.

The disc pattern was represented by two coal cutters, one a Diamond standard compressed - air machine, fitted with double-acting tandem cylinders, which is the type recommended by the firm for thin seams, the overall height being less than 18in. ; the other, a two-motor standard Diamond electric disc machine of the latest pattern. The motors of the latter machine are of the direct-current type, wound for 500 volts, and each is capable of developing continuously 18b.h.p. All the cables on this machine are entirely enclosed, but at the same time are easily accessible. A tramway-type controller is used with magnetic blow-out and a separate fuse chamber. The switch-lid, the fuse-chamber lid, and the cable plug are all automatically locked when the current is switched on, and cannot be opened or removed till the current is off.

The Diamond Company's chain-type longwall machines were also in evidence, two of these being of a quite new and improved pattern. The 1908 type compressed-air Diamond chain cutter is operated by an enclosed high-speed double-acting three-cylinder engine running in oil, and the power is transmitted by similarly enclosed and lubricated steel spur gears. The chain jib of this machine is at the rear end, and can be swung through an arc of 180deg. Reversal of the cutter chain is performed through a bevel and clutch arrangement as used in motor-car construction, which is simpler and more convenient than reversing the engine. This machine is suitable for thin seams, standing only 18in. high, and much steadier running is obtained by the use of the three double-acting cylinders than was the case in the older forms.

The 1908 type electrically-driven Diamond chain cutter is fitted with a 24b.h.p. (direct

or alternating-current) motor, and it is claimed that the reduction gears are of a simpler form and more efficient than in any other machine of this type. The gears are of steel throughout, are enclosed and run in oil. The chain jib parts are interchangeable with those of the compressed-air machine, and the overall height of the cutter is 19in. and the length only 7ft. 6in. This cutter is particularly suitable for short faces where a comparatively light and small machine is necessary and one that will cut its own way under the coal.

A two-motor Diamond longwall chain machine was also exhibited, this being of the over-cut type to remove a parting at any height from 20in. upwards from the floor. This is a machine identical with many in use and which are doing remarkably good work. The débris removed is carried by the cutters over plates provided for the purpose and deposited direct into the gob. This machine is specially adapted for long faces and will cut equally well in either direction. All the Diamond longwall electric coal cutters as shown are fitted with reversing switches having magnetic blow-outs and are designed to cut backwards and forwards.

The firm also exhibit a section of their latest type improved Blackett underground conveyer. The discharging end shown is fitted with a specially designed electric motor which fits under the trough in the same way as the well-known Blackett compressed-air engine. Hitherto no electric motor of sufficient power has been devised to go into this space, but the Diamond Company have now succeeded in overcoming this difficulty. A further improvement is shown in the recently patented epicyclic gears, which are entirely enclosed, run in oil, and which occupy so small a space that one does not suspect their existence. In this little gear box 10h.p. is transmitted and the speed reduced in the ratio of 16 to 1.

The Blackett high-speed enclosed compressed-air engine was also shown together with some intermediate sections of this well-known coal face conveyor.

The Diamond Company's stand, which was one of the most prominent at the Exhibition, also contained examples of their latest pattern underground electric switches and other electric equipment, percussive channelling machines, electric and other boring tools and the usual accessories connected with machine mining.

"Sirocco" Fans.

The "Sirocco" Fans, as made by Davidson & Co., Ltd., are as well known to the power station and iron works engineer as to the mining man, by reason of the fact that whether it be induced draught, furnace blowing or mine ventilation which is the work in hand, these fans are acknowledged as typical of the best practice and have achieved universal popularity in the engineering and mining world by reason of their strong construction and high volumetric efficiency. These fans can be designed for passing, with equal efficiency, large or small volumes against high or low water-gauges, while the cost of installation, due to their comparatively small size per output, is remarkably low.

In the case of mining fans, to reduce the area of metal exposed to the corrosive action of the mine gases the fans of large diameter are supplied with a special housing, so that brickwork may be used as far as possible. At the same time the casing is so designed that, by the removal of a few plates, the fan wheel may be readily rolled into and out of position. Whilst fully-housed fans—*i.e.*, with casings entirely of metal—are supplied in the smaller sizes, they can also be furnished in the larger sizes if specially desired.

Sirocco mine fans are made in two standard designs, viz., single inlet fans and double inlet fans, the capacity of the latter being approximately double that of a single inlet fan of the same diameter but having half its width.

Messrs. Davidson's exhibit included a working example of a 49in. fan of the single inlet type. This size has a capacity of 26,000 cubic feet of air at 3in. water-gauge, when running at a speed of 420r.p.m. In order to show the capabilities of this fan under actual working conditions on a mine, a test box, measuring 15ft. long by 6ft. by 6ft., was fitted to the suction inlet, to represent the fan drift of a mine. By the use of a diaphragm, representing the equivalent orifice of the mine, an artificial resistance was set up to the free flow of the air, and corresponded to the frictional resistance of the underground airways. A recording water-gauge indicated the resistance thus produced.

The mouth of the box was divided by a wire screen into equal parts for anemometer readings, while an automatic water-gauge, made by W. H. Bailey & Co., Ltd., Manches-

ter, recorded the suction set up in the suction drift.

The fan was shown direct-coupled to a Mather & Platt motor, having an output of 20h.p., at 300r.p.m. to 450r.p.m., when running off a 220-volt circuit. The switchboard, also of Mather & Platt's make, comprised voltmeter, ammeter, starting switch, regulator, and fuses, all enclosed in a gas-tight iron case, the switches being operated by projecting handles and the panel designed for underground colliery work.

There was also shown a Sirocco standard centrifugal fan of light construction, measuring 35in. in diameter, and capable of delivering from 13,000 to 51,000 cubic feet per minute against ½in. to 8in. water gauge when connected up to drifts of suitable area. This type of fan is largely used for auxiliary underground ventilation, and may be arranged for belt-drive or for direct-coupling to a motor. Sirocco fans of standard construction are also employed for the ventilation of shafts during sinking operations, as, by varying the speed, they can set up the higher water-gauges as the depth of the shaft increases. They are built in sixteen different standard types, in sizes from 5in. upwards.

Of interest also was the small fan and motor test set so arranged that the Sirocco fan, measuring 5in. in diameter, discharged into the test box, an artificial resistance being produced by reducing the area of the outlet of the box. The fan, driven by an electric motor, was capable of passing 275 cubic feet of air per minute against 1¼in. water-gauge, when running at a speed of 2400r.p.m.

Other exhibits included a model of the Sirocco mine fan installation at Pelton Colliery, Co. Durham. The Sirocco fan, which measures 6ft. 3in. in diameter, is exhausting a larger volume than the combined output of the two large Guibal fans, which measure 30ft. and 36ft. respectively.

Motors for Mining Service.

THE exhibit of Dick, Kerr & Co., Ltd., included a very interesting selection of plant which showed how very closely this well-known firm has studied the exacting conditions which are to be met by electrical machinery in and about mines.

Arranged about the stand were to be noted samples of the various standard motors made by the firm, including a range of four sizes of standard direct-current motors up to 35h.p. One of these motors was fitted with a reduction gear, sub-base and countershaft, the countershaft being arranged in the sub-base fitted underneath the motor, an arrangement altogether very neat and compact and strongly constructed. A range of standard alternating-current motors was shown, including both squirrel cage and wound rotor types with slip-rings; these follow the well-known standard design of Messrs. Dick, Kerr & Co. There was also exhibited a range of standard designs of crane motors, which well repaid inspection. One or two of the motors were fitted with the D.K. special automatic magnetic brake, which comes into operation immediately current is switched off the motor. This is a very simple and efficient type of brake for use in connection with crane work and other special applications of this type of motor where some form of brake is necessary. Also there were to be seen various types of standard motor starters, controllers, &c., for operating and controlling the various types of motors, particular attention being directed to the types specially designed to conform with the Mining Regulations, including the oil-immersed auto-starter for squirrel cage motors, the type shown being a very fine example of this switch. The samples of "R" type controller shown were also well worth inspection, as being of neat, compact, and very strong construction; these controllers are fitted with the patent magnetic blow-out which is one of the most valuable features of all Messrs. Dick, Kerr & Co.'s controllers, circuit-breakers, &c.

A specially interesting exhibit was the complete electric capstan, which, while being arranged on the usual lines of this type of machinery, has a number of novel features making for increased simplicity and efficiency of operation. A very interesting feature of this exhibit was the contact type of starter shown, which is independent of the starting switch. After the circuit has been closed through the starting switch by depressing the starting pedal, the contactors automatically come into operation, cutting out resistance and starting the motor in the usual way; on the release of the pedal or the operation of the overload device, the switch and the contactors come back to their normal position. With this

arrangement it is impossible to start the motor too rapidly, and thus all starting switch troubles due to carelessness of the operators are eliminated. The starting switch itself is fitted with an overload and no-load release, and has the familiar patent Dick-Kerr blow-out fitted. The drive to the capstan head is through worm gear and the other construction of the capstan follows the usual practice, with the exception that the cast-iron case is made water-tight by a special arrangement of the joints.

Various component parts of stationary motors were shown, together with samples of the different apparatus used in colliery and general electrical work, such as oil-switches, isolating switches, current transformers, circuit breakers; also a complete standard motor-starting switch panel, with double-pole switch, fuses, ammeter, and the special slow-movement starter patented and manufactured by Messrs. Dick, Kerr & Co. This type of starter is well worth attention on account of the simple device which prevents any motor under its control from being started up too rapidly by workmen or others, thus preventing injury to the motor. However fast the operator may endeavour to switch on the motor, he can only cut out resistance one contact at a time, and at a safe speed. The patent magnetic blow-out above referred to is also fitted to all these types of starters.

There were also to be noted various samples of the material manufactured at the Company's general engineering works at Kilmarnock, including a standard type tipping wagon, small turntable, set of points and crossings, and various examples of light railway track work with iron sleepers.

The whole formed a very interesting exhibit, and gave exhibitors an excellent idea of the smaller material turned out from the electrical works of Messrs. Dick, Kerr & Co. at Preston and their general engineering works at Kilmarnock.

A number of interesting photographs of actual installations which have been carried out by this firm at various collieries, mines, &c., were to be noted arranged about the stand.

We are informed that the business of Messrs. H. W. Ward & Co., machine tool makers, Birmingham, has been registered as a private limited company with a view to the further extension of the business. With the increased facilities these arrangements will provide, the firm intend holding larger stocks of their standard products, so that their machines may be more readily obtained.

New Catalogues.

Induced Draught.—Matthews & Yates, Ltd., Manchester. This firm has just published an interesting little booklet on the subject of induced draught in connection with steam boilers. The booklet contains a number of illustrations and copies of testimonials from well-known firms who have adopted the system. Readers who are interested in this can obtain a copy of the pamphlet on application to Messrs. Matthews & Yates.

Measuring Instruments.—General Electric Company, Ltd., London. Section List No. M1249 is a very comprehensive and well-got-up catalogue, giving particulars and prices of a wide range of instruments—ammeters, voltmeters, wattmeters, electricity meters, &c.—to suit all grades of work.

Cables.—Johnson & Phillips, Ltd., Charlton, S.O. This company has issued a revised edition of its cable catalogue, which, it is claimed, and with some justification, is the most complete and up-to-date vulcanized indiarubber cable and wire price-list issued by any cable firm in this country. Copies may be obtained on application. It is also of interest to note that Messrs. Johnson & Phillips are reducing the price of their association grade cables, wires, and flexibles by quoting bigger discounts to the trade.

Gas Engines.—Kynoch, Ltd., Birmingham, send us an illustrated catalogue giving particulars and prices of their various types of gas engines. The list also includes a short description of the Kynoch suction gas plant, and a table of the approximate shipping weights and measurements both of the gas engines and the suction gas plant.

Armature Truck.—H. C. Slingsby, Bradford. List 102 gives particulars and prices of a hand-truck designed specially for the quick and safe handling and conveyance of armatures.

Coke-Oven Chargers.—W. J. Jenkins & Co., Ltd., Retford, have produced a well-illustrated booklet descriptive of their "D.B." projector for coking plants. This plant is suitable for electrical operation, and is to be seen at the Franco-British Exhibition, Stand 168, Machinery Hall.

Installation News.—Simplex Conduits, Ltd. The July number of this monthly bulletin is interesting reading, giving an account of the firm's annual outing, conduit wiring practice, tests of metal filament lamps, &c., as well as notes of the most recent introductions of Simplex fittings.

Prepayment Meters.—The Rochdale Electric Company, Ltd. Along with copy of catalogue describing the "Watson" prepayment electricity meters, the makers send advice that these meters have been adopted and are to be seen at the Franco-British Exhibition in connection with both the direct-current and alternate-current supplies.

The

Electrical Magazine.

VOL. X. NO. 3. LONDON. SEPTEMBER 15th, 1908.

The World's Electric Progress.

The Manchester Electrical Exhibition.

ON October 3rd is to be opened the Manchester Electrical Exhibition, which promises to be one of the most successful and popular trade exhibitions ever held in this country. Elsewhere in this number is given a list of the more important exhibitors, from which it will be seen that electrical manufacturers are well represented both as to number and variety. THE ELECTRICAL MAGAZINE has taken space, and readers are cordially invited to pay us a call at the stand; they will find very much that is of extreme interest, and our services are at their disposal for such information or guidance as may be desired.

During the run of the Exhibition, on October 15th, will be published a Double Number of THE ELECTRICAL MAGAZINE, in which will appear a series of special articles, written by practical experts, dealing with those branches of applied electricity which are of the greatest interest to workers in the great industrial area of Manchester and its surrounding districts. The latest practice in the adoption of electricity in textile factories, collieries, machine shops, &c., will be fully dealt with. In addition there will be included descriptions of the more noteworthy exhibits, giving those facts and particulars which are novel and likely to prove of the greatest practical value to readers.

Exhibitions have been so frequent of late that more than once we have been led to criticise the methods adopted by some exhibiting firms; without going into details at this time, we may venture to remind our enterprising electrical friends who are to be represented at Manchester of one or two golden rules:

Place a responsible man in charge on the spot, this is work for an experienced salesman—don't leave the exhibit to the care of a hired messenger boy, or any temporary, unskilled person to distribute pamphlets and to refer enquirers to head office.

Consider all enquirers as of value—they may not be actual buyers, but who can say what apparently insignificant attention or courtesy will not be the means of influencing business? Every salesman knows of cases where a mere triviality has been the means of turning an order one way or the other.

Remember that an exhibition is entirely a means of advertising, and it rests with each exhibitor to do his share towards bringing the visitor along; it is not sufficient to take a space and stop at that; let it be known broadcast that you are there to welcome comparisons and criticisms. An advertising scheme of this character is complete in itself, and the uncompleted scheme is little, if any, better than none at all.

Experience in Cable Laying.

A GOOD deal of controversy has arisen of late years concerning the effect of corrosion due to electrolysis on various classes of cable, and the whole subject of cable-laying has undergone a considerable amount of revision. The following information sent us by a correspondent is of considerable interest as being the results of experience obtained in a system of mains comprising about thirty miles of high-tension cable and eighty miles of low-tension mains; the greater portion of which has been at work about ten years.

The good results obtained seem to indicate that trouble from electrolysis need not be expected if the methods mentioned are followed, inasmuch as the examples are drawn from a district in which electrolysis might be reasonably expected to occur due to the presence of a heavy electric tramway system. When the low-tension mains were laid the system adopted was that of laying direct in the ground, the lead covering being juted, armoured, and overlaid with an outside protection of impregnated jute. It was found that the double covering of jute, together with the armouring, was quite sufficient to protect the cable sheath, not only from any corrosion, but also from mechanical shock or strain due to any subsidence likely to occur in a manufacturing centre.

At a later date extensions were effected by laying the mains on the solid system, the troughs being placed in a trench direct on the earth, and plain lead-covered cable laid solid in these troughs. In order to keep the lead from the bottom of the trough either earthenware bridge pieces were placed at frequent intervals under the cable, or else rope or yarn was laced round the sheathing. It is not essential to make the bridges of porcelain, as in another instance the necessary support was supplied by means of bridge pieces made of impregnated wood, and in yet another instance pieces of strip iron bent to a suitable shape and carrying the cable as in a hanger were employed. The precaution was, of course, taken to keep the troughs as dry as possible and free from earth, and they were filled in with gas works pitch which had been refined before using. In cold weather the pitch was thinned out with a little thinning oil, which made it run better and much less liable to crack. Careful supervision was necessary over the labouring gangs in order to ensure the proper filling of the troughs, and it is our correspondent's opinion that a good many cases of breakdown in this class of mains may be due to insufficient supervision when laying.

Where changes of level occurred in the run of the cable, care was taken to see that the troughs were always filled at the highest point of any vertical curve. The covering bricks were made of specially hard rough slag, 4½in. by 9in. by 2in., either dipped entirely into pitch or else completely covered over one face with pitch and then placed on the trough. This simple precaution keeps them tightly in place, and prevents them from shifting if the ground is disturbed. The troughs were then filled up to the top by taking a brick out here and there and pouring in until an overflow took place. Where there was any great weight on the ground due to the placing of two or more troughs, one above the other, a layer of, say, 3in. thick was required, unless the ground happened to be very firm.

A third method of laying adopted for high-tension cables, lead covered type, was to draw them into pipes, and here, in order to provide protection for the lead, one layer of jute was provided, this necessitating a somewhat careful handling, inasmuch as there was a tendency when drawing in the cable for the jute cover to ruck up and lay bare the lead sheathing.

It was, of course, necessary to earth the lead sheathing of the cables together at the generating stations and sub-stations in order to distribute any chance potential, and this precaution, together with the fact that the disconnecting boxes being earthed to the wire connecting the two leads together (the boxes having compound glands) made earths

on the bottom of the boxes, appeared to render the lead sheath quite free from potential.

In the case of high-tension cables drawn into the pipes it was found that to a great extent these pipes were filled with water and this acted as a sufficient earthing device from the cable to the surrounding wet soil. When traction mains were laid these were carried out with lead-covered cables pulled into ducts, separate boxes being provided for traction and lighting mains. A further earth was obtained by means of the water which lay in the ducts, and although the tramway system in the area was a very extensive one and heavily worked, no trouble arose during at least four years' run of the tramway system.

The disadvantage of the solid system was in the practical application thereof. It is very difficult to carry everything out completely, as to do so one has to insulate the lead sheath, the iron boxes, the service cable, and all other parts of the system. This is almost impossible in practice, more especially where extensions or repairs are to be made, inasmuch as it is very difficult to get at a fault. This is aggravated by the fact that a cable may break down, developing a fault which may heal itself again with the melted pitch; this combined with the fact that, where ducts filled with solid compound or pitch are laid over one another, the location of a fault is very difficult to get at, renders the solid system somewhat difficult to maintain in its initial stage of perfect insulation of sheathing.

Where, however, care is taken in the initial lay-out of the system and in subsequent repair and extension work, the solid system is probably the best preventive for any trouble connected with electrolysis on the lead sheathing of cables.

On Writing for Publication.

ONLY a very small percentage of engineering workers ever attempt to record the results of their experience or working ideas for the purpose of publication. It is remarkable that this should be so, for there are very many advantages, other than the lucrative, to be gained by the contributor to trade journals. There is no more sure way of establishing a prominent position in the engineering world than to have one's name repeatedly cropping up as an author; and as opportunities for advancement occur, to be well known as a writer is to have a good start against competitors, for the indisputable reason that the ability to write a lucid and convincing article proves the writer's definite knowledge of the subject treated. In this connection we would take the opportunity of reminding the student that the safe test of his having mastered a problem is to leave the text book alone and to write an account of it to his perfect satisfaction; as an aid to study he will find that the little writing often means far greater progress than much reading. Moreover in these days of written examinations, with certificates forming one of life's essentials, only the ready, accurate writer can aspire to the high awards. In fact is it not true that education to-day is nothing more than a training to write a multitude of small essays on as many different subjects in record time? That being so, why should the average man, having completed his "education" in that sense, be so chary about writing for publication? There are many reasons given, but few are satisfactory, especially in the case of the younger man who thus refuses to use one of the finest levers for advancement.

Some seem to think that they have nothing original to write about; practical engineering probably offers more in the way of a constant exercise of ingenuity than any other calling, and what may appear as the simplest of everyday work to one will appeal to thousands as of originality and value.

There are many who apparently have the impression that the realm of technical journalism is bounded by some mystic circle which precludes any but the favoured few, that the editor is above all a judge of punctuation and spelling, that he won't look

at anything but what is neatly typewritten, and so on. Grant that it is hard work to many men to write in good and correct style, and that it is an expense to have matter typewritten, but neither beauty of composition nor machine-typed manuscript are necessary; if an article contains information which will benefit his readers, the editor will use it, be it never so roughly inscribed.

Very much could be written on this subject, but we hope that sufficient has been said to quicken the reader to the possibilities and advantages of technical journalism. We shall be pleased to have readers submit manuscripts to us for consideration, and would particularly welcome those of the working electrician or mechanic describing difficulties faced and overcome in the course of an outside job or work in the shops.

Trade with Chile.

WRITING of the opportunities which Chile affords as a market for the United States engineering manufacturer, M. de Moreira in the *American Machinist* laments the fact that England and Germany hold the lead, as yet, in the development of this progressive South American Republic.

	1906.	1907.	Decrease or Increase.
Imports	$ 86,759,639	$107,193,877	+$20,434,238
Exports	105,711,811	102,229,456	– 3,482,355
Total trade	$192,471,450	$209,423,333	+$16,951,883

The above table shows the large rate of trade increase in Chile. It is interesting to know that the value of machinery and tools imported in 1906 amounted to $14,646,611 against $17,469,249 in 1907, and that about half of this import belongs to England; the other half is divided between Germany, France, United States and Belgium, the individual amounts decreasing in the order named.

Much has been done toward developing railways in Chile. The year 1907 saw the completion of several short lines that have opened up important sections not reached by the main lines; the Government have also started the line paralleling the coast from Arica to Puerto Montt. The state railways have lately purchased 60 locomotives, 75 passenger cars and 1200 freight cars. Out of this large purchase for a small railway country, the United States has supplied only 25 locomotives and 60 passenger cars. Ten different lines of railway is the extent of the present Chilean rail transportation, but these lines are becoming larger every day and need new material and supplies. Once the Isthmian canal is opened and the railway from Valparaiso to the Atlantic coast finished, through Chile will be the quickest route from New York to Buenos Ayres.

Not only have Chilian railways increased, but the merchant marine as well. The last official statistics give Chile 85 steamers and 90 sailing vessels with a tonnage of 110,000 tons.

After Brazil and Argentine, Chile has the best navy in South America, and the Government maintains very good repair shops along the coast. Docks are being built, all the steam cranes employed to handle freight at Valparaiso being of English make.

An opportunity for trade is the electrification of a considerable portion of the lines which are now operated by steam. Coal is of excessive cost, being nearly all imported from Cardiff and Australia, and the Government naturally is anxious to reduce the cost of operation.

One of the proposed electrical power plants is the transformation of a large steam-power plant at Santiago de Chile into a hydro-electric plant of a capacity of no less than 20,000h.p. This plant will furnish light and power for Santiago de Chile and vicinity, and will be worked on the same plan as the Sao Paulo Light and Power of Sao Paulo, Brazil, giving to the city a good and up-to-date car system. An electric railway of 10 miles in length is to connect Talcahuano with Concepcion; the power plant of the line will be of 1500h.p.

The German Transatlantic Electric Company has a concession to erect a hydraulic electric-power and lighting plant on the river Maipo, above Santiago, at an estimated cost of $4,015,000, of which $1,295,040 will be imported for materials and machinery.

The Chilean nitrate year, 1907-8, ending March, 1908, shows a total production of nitrate of 4,159,084,858 pounds, which is an increase of over 1,000,000 pounds over the previous year. At the opening of 1907, the nitrate works numbered 121; all are operated by machinery almost exclusively of English make.

*A New Large Generator for Niagara Falls.**

B. A. BEHREND.

A NEW generating plant of considerable magnitude has been completed recently at Niagara Falls. This is the new plant of the Niagara Falls Hydraulic Power and Manufacturing Company. A number of large direct-current generators to be used for the manufacture of aluminium have been installed, each of these generating units consisting of two direct-current generators connected to 11,000h.p. turbines. A large alternating-current generator, one of an aggregate of three wound for 12.000 volts, has also been installed in this station. The power house is located at the foot of the falls, on the American side, below the old power house of the Niagara Falls Hydraulic Power and Manufacturing Company.

The generator, which is described in this paper, offers a number of interesting features, and is remarkable among the generators at Niagara Falls on account of its speed of 300r.p.m., which is greater than the speed of any of the other large generators installed in the power houses at the Falls. The generator is wound for 12,000 volts, three-phase,

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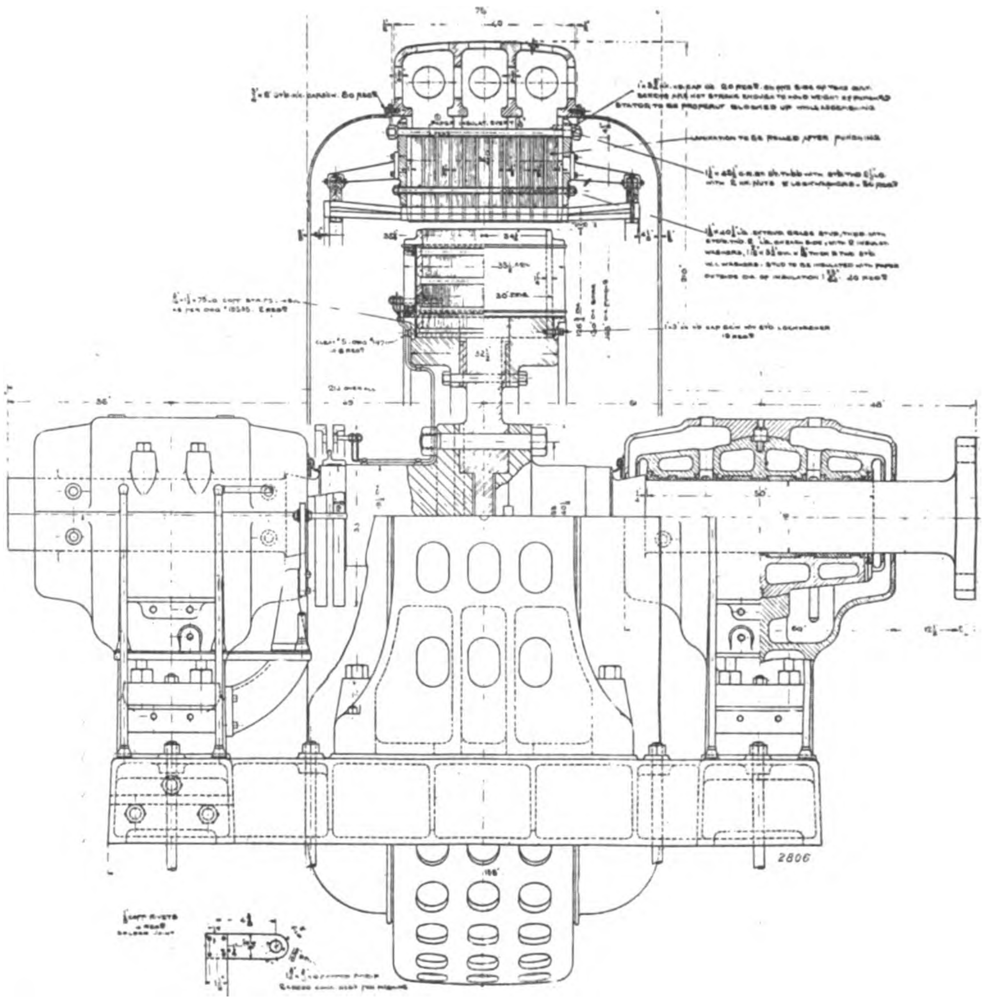


FIG. 2. SIDE ELEVATION OF 10,000H.P. GENERATOR.

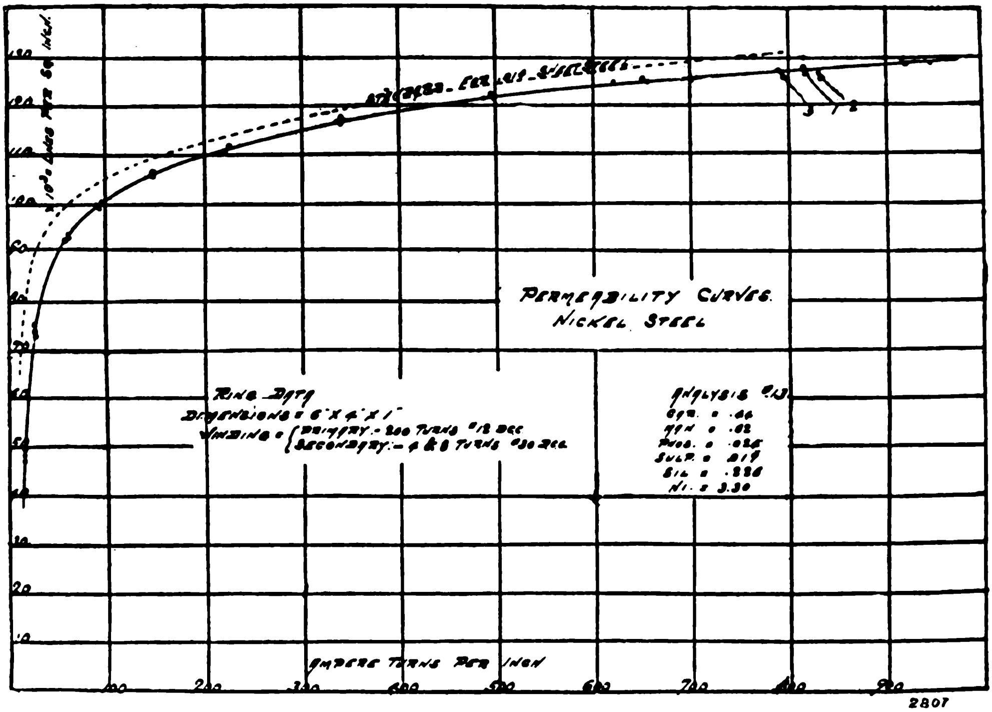

PERMEABILITY CURVES.
NICKEL STEEL
RING DATA
ANALYSIS
CAR. = .44
MAN = .62
PHOS. = .026
SULP. = .019
SIL. = .226
NI. = 3.30
AMPERE TURNS PER INCH
100
200
300
400
500
600
700
800
900
2807

Fig. 3.

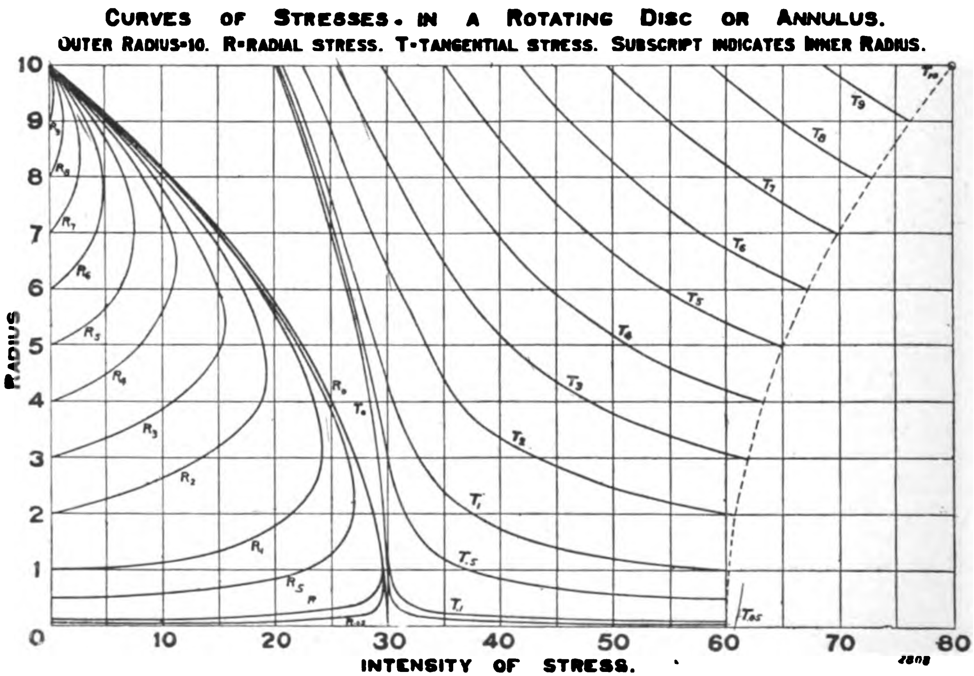

CURVES OF STRESSES IN A ROTATING DISC OR ANNULUS.
OUTER RADIUS=10. R=RADIAL STRESS. T=TANGENTIAL STRESS. SUBSCRIPT INDICATES INNER RADIUS.
RADIUS
INTENSITY OF STRESS.
0
10
20
30
40
50
60
70
80

Fig. 4.

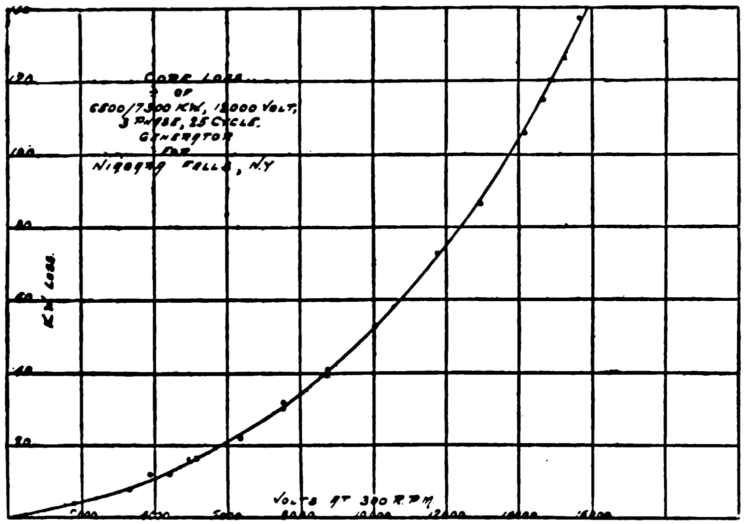


FIG. 5. CORE LOSS OF 10,000H.P. GENERATOR.

tails of this interesting unit. The construction of the rotor is worthy of careful study. A disc of nickel-steel, without a hole in the centre, forms the middle part of the revolving element. Two nickel-steel rings are mounted on each side of this web, and are bolted and keyed to it. The nickel steel used for this construction must have great mechanical strength and high magnetic permeability. A nickel-steel containing 3 5 per cent. nickel has been used for this purpose. Its elastic properties are :—

Elastic limit	50,000lb. per sq. in.
Ultimate strength..	80,000lb. per sq. in.
Elongation	20 per cent. in 2in.
Reduction of area	40 per cent.

The magnetic qualities of this steel are given in the curve illustrated by Fig. 3.

25 cycles. The water-wheel is mounted on a horizontal shaft, and has a capacity of 11,000h.p. The generator is rated at 6500kw., with a capacity for continuous operation of 7320kw., or approximately 7500kw. The runaway speed of the water-wheel is given as 506 revolutions ; the generator, therefore, had to be designed to be safe at this speed.

The experience which has been gained from the design of generators for direct connection to steam turbines has greatly minimized the difficulties of a problem like the one under consideration. Nevertheless, 11,000h.p. generating units are neither so plentiful nor so readily designed and built as not to afford considerable interest, especially if the results obtained with such machines are remarkably satisfactory.

The assembly drawings, Figs. 1 and 2, show the most important de-

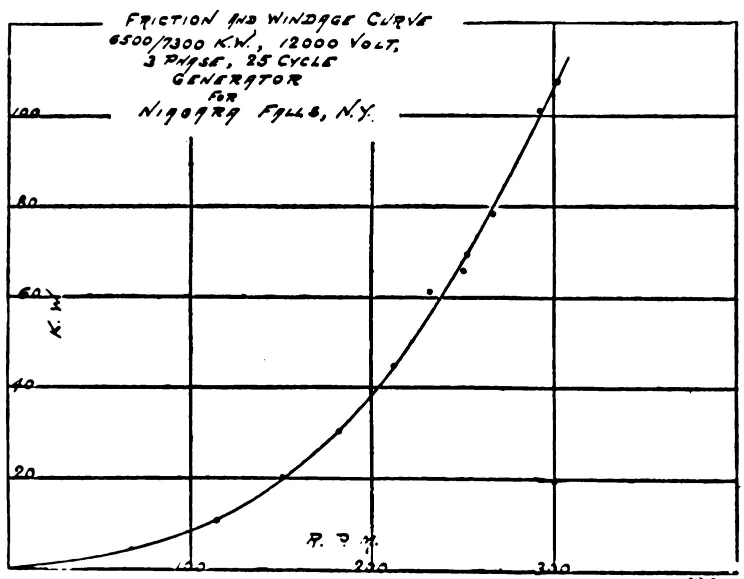


FIG. 6. FRICTION AND WINDAGE CURVES OF 10,000H.P. GENERATOR

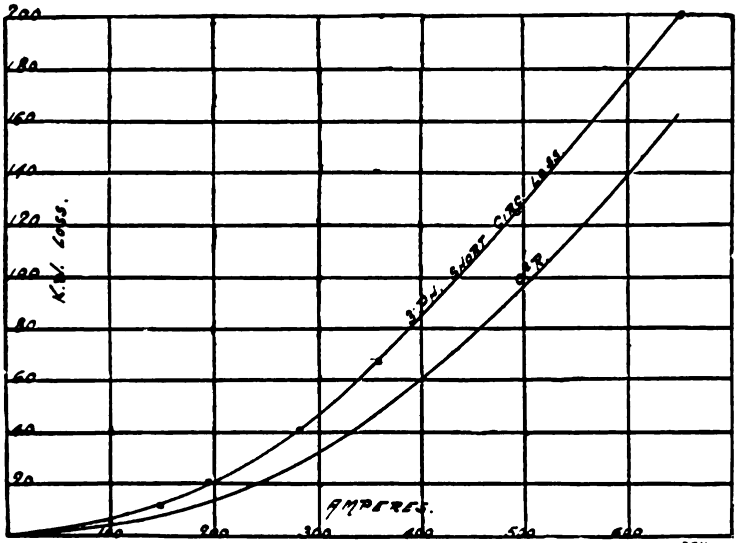
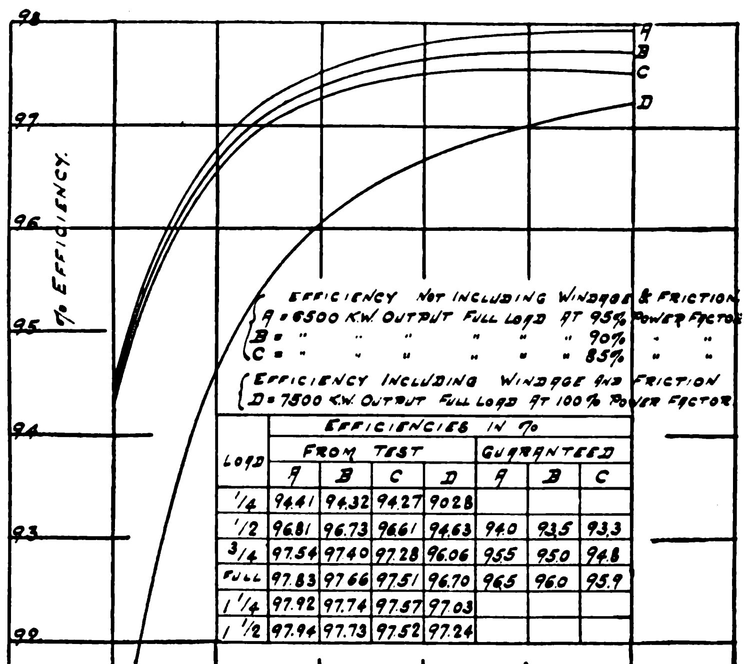


FIG. 7 SHORT-CIRCUIT CORE LOSS OF 10,000H.P. GENERATOR.

The nickel-steel forgings as used in this construction enable the designer to produce the strongest and lightest construction, as the mechanical strength of the material is great and the magnetic permeability high. The weight of the complete rotor is only 92,900lb., and, the bearings being 16in. by 50in., the specific pressure is only 58lb. per square in. The weight of the stator is 116,700lb., and the weight of the entire machine is 275,000lb.

It may be of interest to discourse briefly upon the theory of elastic stresses in rotating discs and rings. The theory of elasticity applied to the radial and tangential stresses in rotating discs shows that the point of maximum stress is at the centre of a disc and at the inside surface of a ring. We have demonstrated the correctness of this theory by experiments with lead discs, the deformation of which, as obtained by measurement before and after the test, readily indicates that the maximum deformation, as shown by the lateral contraction, appears at the centre of the discs or at the inside of the ring from where the metal flows toward the outside portions. The radial stress normal to a free surface must be zero, and, therefore, the maximum stress appears at a tangential stress. In a solid disc the elements at the centre are subject to both radial and tan-



LOAD	EFFICIENCIES IN %						
	FROM TEST				GUARANTEED		
	A	B	C	D	A	B	C
1/4	94.41	94.32	94.27	90.28			
1/2	96.81	96.73	96.61	94.63	94.0	93.5	93.3
3/4	97.54	97.40	97.28	96.06	95.5	95.0	94.8
FULL	97.83	97.66	97.51	96.70	96.5	96.0	95.9
1 1/4	97.92	97.74	97.57	97.03			
1 1/2	97.94	97.73	97.52	97.24			

FIG. 8. EFFICIENCY CURVES OF 10,000H P. GENERATOR.

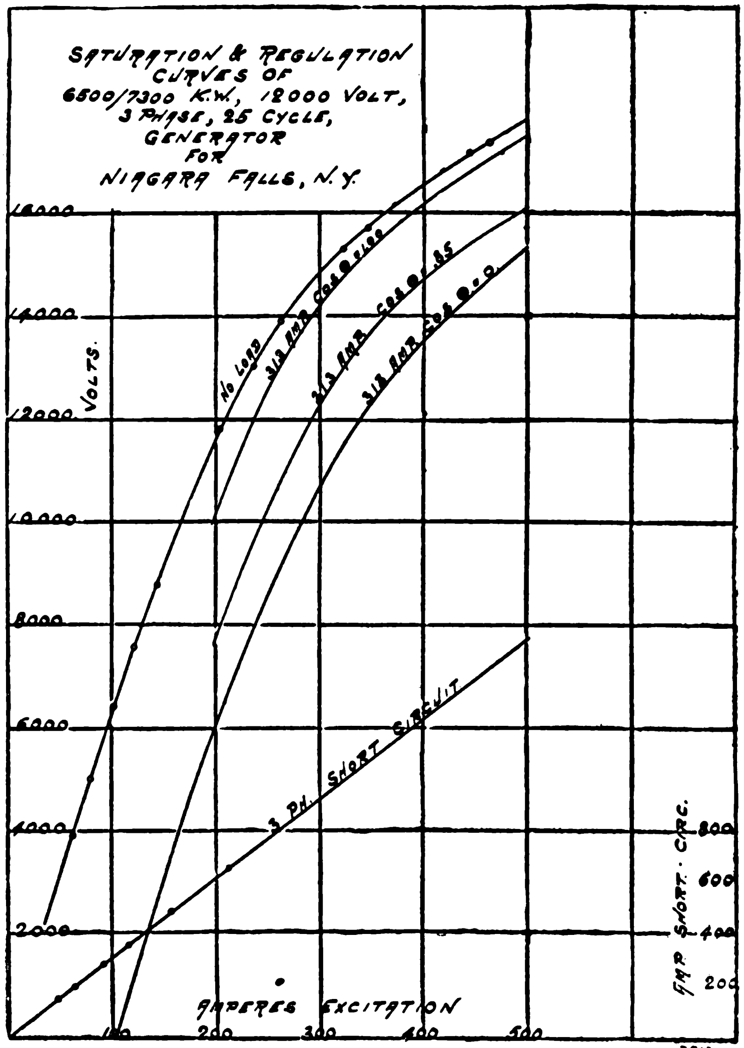


FIG. 9. SATURATION AND REGULATION CURVES OF 10,000H.P. GENERATOR.

gential stresses. A hole in the centre eliminates the radial stress, and, as is shown by the theory, this doubles the tangential stress. This is well illustrated in the curves shown in Fig. 4, in which the radial stresses are shown by the abscissæ on the left of the curve sheet, and the tangential stresses are shown by the abscissæ on the right of the curve sheet. It is assumed that the outside radius of the disc, or the ring, is kept constant and equal to 10 units of length, while the inside radius is increased from zero to 10 units of length. The radial and tangential stresses are then represented by the abscissæ of the two sets of curves shown in the figure.

Great mechanical strength and lightness are obtained in this rotor construction, and although it would have been possible to use a hub mounted on a shaft, according to the practice with slow-speed machinery, as the stresses on the inside of the hub would not have been prohibitive, the design adopted for this large generator is elegant and mechanically superior. The electrical characteristics of this unit are well shown in the curves, Figs. 5 to 9.

Fig. 5 represents the core-loss, which is equal to 75kw. at 12,000 volts; this is approximately 1 per cent. of the output.

Fig. 6 represents the power necessary to overcome the friction and windage at 300r.p.m., which is equal to 106kw.

Fig. 7 represents the short-circuit core-loss of the generator, demonstrating that the ratio of the short-circuit loss to the I^2R loss at 7500kw. is equal to 1.45, which is a very excellent result.

Fig. 8 shows several efficiency curves and a tabulation of the guaranteed efficiencies compared with the actual efficiencies.

Fig. 9 represents the saturation and regulation curves of the generator with a regulation of 8.4 per cent. at full load and 100 per cent. power-factor at 12,000 volts. The generator is capable of giving 13,000 volts under any condition of load that is likely to occur should this be required. The temperature will remain within 35deg. at normal load and 40deg. at 7500kw.

THE TESTING OF ALTERNATING-CURRENT GENERATORS.

J. W. ROGERS.

THE tests generally carried out in modern testing shops on alternating-current generators may be considered under two distinct heads, viz., experimental and commercial.

Experimental Tests.

Experimental testing is carried out on all machines of new design for the purpose of obtaining information with reference to their performance under working conditions, and also to prove accuracy in design. The experimental tests required are: (1) Resistance; (2) open and short-circuit characteristics; (3) iron loss, saturation, and friction; (4) regulation and efficiency.

Resistance.

As is well known, the armature of an alternating-current generator may be wound for generating either single, two-phase or three-phase currents, so that the method of measuring the armature resistance will depend upon the type of generator under test. In the case of a single-phase generator the armature resistance is simply the resistance as measured between the machine terminals. It is found by the drop of potential method, then the total armature resistance R =

Volts drop between terminals ÷ current.

With a two-phase generator there are two separate circuits to be taken into account, so that the total armature resistance R will only be half the resistance as measured between the two terminals of either phase.

$$\therefore\ R = \frac{\text{Volts between terminals of one phase}}{\text{Current} \times 2}$$

As regards a three-phase generator, its armature may be connected up in either star or mesh fashion. Taking the case of a mesh-connected winding, the resistance between any two terminals is the resultant of one phase in parallel with the other two phases in series. So that if r represents the resistance of one phase, then

$$r = \frac{r \times 2r}{r + 2r} = \frac{2r}{3}$$

That is to say, the resistance of one phase =

$$\frac{\text{Resistance between terminals} \times 3}{2}$$

With a star-connected winding the resistance as measured between any two terminals is that due to two phases in series with each other, so that the resistance of one phase =

Resistance between terminals ÷ 2

The total resistance R of a three-phase armature =

$$\frac{R_1 + R_2 + R_3}{3 \times 2}$$

where R_1, R_2, R_3 = resistances between terminals.

∴ Total resistance =

$$\frac{\text{Mean resistance between terminals}}{2}$$

which is the same as the expression for a two-phase armature.

Strictly speaking, the value of ohmic resistance obtained with the drop of potential method is not correct, as the actual resistance is always greater when an alternating current flows through the windings, due to what are known as eddy-current losses. With small conductors the difference between the apparent and actual resistance is

very small, but in the case of large conductors the error is considerable. A knowledge of the total resistance of an armature enables its copper loss to be calculated. The copper loss in either a two or three-phase armature is given by $\frac{C^2 \times R}{2}$, where R = mean resistance between terminals, and C = total amperes. The total amperes in a two-phase generator = amperes per phase × 2, and in a three-phase machine = amperes per phase × $\sqrt{3}$.

The armature resistance drop between terminals in a three-phase machine =

$$\frac{\text{Mean resistance between terminals}}{2} \times \text{amperes per phase} \times \sqrt{3}.$$

Open-circuit and Short-circuit Characteristics.

These tests are made chiefly to determine the self-induction of the armature, and also the effect of armature impedance in reducing the terminal voltage of a machine when run at a constant speed and with varying field current.

The open-circuit test is made by running the alternator at normal speed on open-circuit with different values of exciting currents, and taking readings of exciting currents and the corresponding values of armature terminal voltage. These readings are then plotted in the form of a curve which represents the open-circuit characteristic of the alternator. This test also serves as a check on the armature windings in the case of a polyphase machine, in which case the voltage readings should be taken across the several phases. The short-circuit test is made by short-circuiting the armature through an ammeter of negligible inductance, and taking readings of armature and field currents. From these readings a curve known as the short-circuit characteristic is plotted, this curve being generally a straight line. The armature current should be about one and a half times its full-load value for this test.

The total short-circuit current for a three-phase generator =

$$\frac{C_1 + C_2 + C_3}{\sqrt{3}} = \frac{3C}{\sqrt{3}} = \sqrt{3}C,$$

with a star winding. Also total short-circuit current = $C_1 + C_2 + C_3 = 3C$ for a mesh winding.

Having obtained the open and short-circuit curves, the value of armature current on the short-circuit curve and the terminal e.m.f. on the open-circuit curve are read off for the same value of exciting current, and the impedance of the alternator armature is represented by the ratio:

$$\frac{\text{Volts on open circuit}}{\text{Amperes on short circuit}}$$

The term impedance represents the total opposition to the flow of current; it is made up of resistance and reactive components, and the relation between the current, voltage, resistance, reactance and inductance of the armature may be obtained from the equation:

$$C = \frac{E}{\sqrt{R^2 + P^2 L^2}}$$

where

C = current.
E = voltage.
L = inductance in henries.
R = ohmic resistance, and
P = $2 \pi n$, where n = frequency of current.

The values of C, E, and R having been obtained from the results of the tests mentioned above, the armature inductance may be calculated by transposing this equation, as follows:—

$$C = \frac{E}{\sqrt{R^2 + P^2 L^2}}$$

$$\sqrt{R^2 + P^2 L^2} = \frac{E}{C}$$

$$P L = \frac{\sqrt{E - C^2 R^2}}{C}$$

$$\therefore \; L = \frac{\sqrt{E^2 - C^2 R^2}}{C P}$$

Another, and perhaps a simpler, method of measuring the inductance of an armature employs the following formula:—

$$\text{Tan } \phi = \frac{\text{reactance}}{\text{resistance}}, \text{ also reactance } = 2\pi n L$$

$$\therefore \tan \phi = \frac{2 \pi n L}{\text{resistance}},$$

$$\text{and } 2 \pi n L = \tan \phi \times \text{resistance}$$

$$\therefore L = \frac{\tan \phi \times \text{resistance}}{2 \pi n}$$

As the value of $\tan \phi = \frac{\sin \phi}{\cos \phi}$, it may be obtained from a table when the value of $\cos \phi$ is known. Owing to the varying effect which an alternator field has upon its armature when their relative positions are altered, there is a fluctuation in the value of the armature inductance. The armature self-induction depends upon its position in relation to the field poles, and has a maximum value when the centres of the armature coils are directly opposite the poles. It also varies with the power factor of the armature current, because the maximum value of the armature current at unity power factor occurs when the centre of an armature coil is midway between two poles; but when there is a difference in phase of the current and terminal voltage, the maximum value of the current will take place when the coils are directly opposite the poles. It will therefore be seen that the values of armature inductance obtained from the tests mentioned above can only be taken to represent the average value under certain conditions.

A more accurate method of obtaining the value of armature inductance consists in passing the full-load current through the armature when stationary, with full-load excitation on the field, and taking a reading of the volts necessary to give the full-load armature current, which will be equal to the resultant of the resistance and reactance drop in the armature. This test is made with the armature in different positions relative to the field poles, and the mean value of armature inductance obtained for each position will represent the effective value under full-load conditions. The inductance is found from the right-angle relation which exists between the resistance and inductive drops. The short-circuit test is sometimes made as a check on the regulation of a machine, and in the case of machines of large output it is only possible to calculate the regulation from data to be obtained from the open and short-circuit curves; but this question will be considered when dealing with the regulation of alternators.

Iron Loss, Saturation, and Friction Loss.

The iron loss occurring in an alternator represents the energy necessary to turn the armature in the excited field at its normal

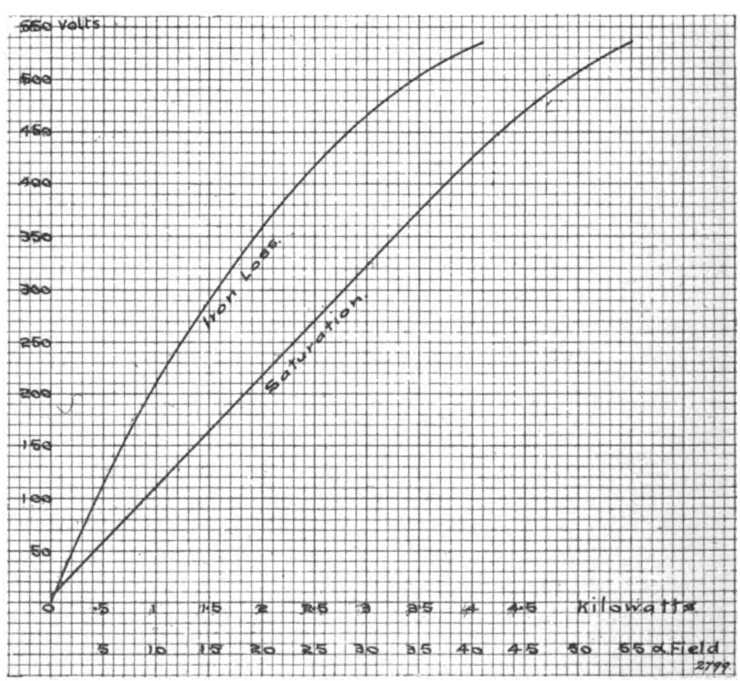


Fig. 1

speed, and it is generally measured by belting the alternator to a shunt-motor, and measuring the energy required to drive the machine with different exciting currents at normal speed. The input to the driving motor = loss in motor armature and field and iron and friction losses in alternator.

This test is made by running the motor up to give the normal speed on the alternator, which must be kept constant, and taking readings of line voltage and armature current on the motor, also terminal volts and field amperes on the alternator under the following conditions :—(1) No excitation on alternator ; (2) varying exciting currents ; (3) motor running light with the belt off. To ensure that the conditions of the test remain constant, it is necessary to take several check readings of the motor input when driving the alternator unexcited. The iron loss in watts for any particular value of exciting current or terminal voltage on the alternator =

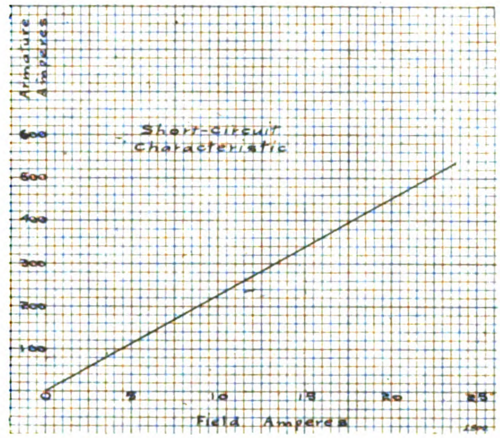


FIG. 2.

Motor input with alternator excited –
Motor input with alternator unexcited.

Similarly the friction loss =

Motor input when driving alternator unexcited –
Motor input with belt off.

Saturation Test.

This test, which is really an open-circuit test, is made for the purpose of obtaining a knowledge of the amount of energy required to magnetize the alternator field. As the same readings are required, this test is generally made in conjunction with the iron-loss test. The following figures give the results of an actual test carried out on a 150kw., 440-volt, three-phase generator, the curves obtained from these readings being shown in Figs. 1 and 2 :—

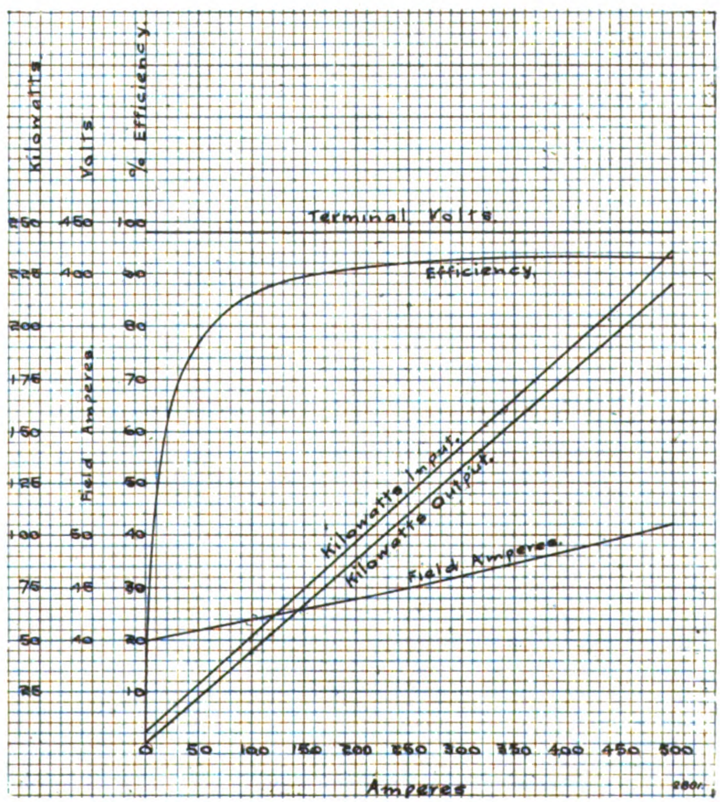


FIG. 3.

TABLE I.—IRON LOSS AND SATURATION.

Motor.				Alternator.	
Terminal Volts.	Armature Current.	Watts Input.	Iron Loss in kw.	Terminal Volts.	Field Current.
132	32	4224	—	5	0
132	33.5	4422	.198	75	7.5
132	36	4752	.528	127	12.1
132	38	5016	.792	174	16.8
132	40.5	5345	1.121	238	21.6
132	43	5676	1.452	284	25.8
132	45.5	6006	1.782	322	30.6
132	32	4224	—	10	0
132	48.5	6400	2.176	380	35.4
132	52	6864	2.64	392	38.4
132	55	7260	3.03	456	43.4
132	58	7656	3.43	504	47.2
132	63	8316	4.09	536	55
132	32	4224	—	10	—
132	20.5	2706	—	Belt off	—

Friction = 4224 − 2706
= 1518 watts.

TABLE II.—SHORT-CIRCUIT DATA.

Motor.				Alternator.	
Terminal Volts.	Armature Amps.	Watts Input.	Lost kw.	Armature Amps.	Field Amps.
132	32	4224	—	0	0
132	36	4752	.528	86.5	3.6
132	41	5412	1.188	173.2	7.7
132	50	6600	2.376	264.5	11.6
132	60	7920	3.696	357.8	15.5
132	79	10428	6.2	446	20.3
132	99	13068	8.84	534	23.7
132	32	4224	—	—	—

Regulation and Efficiency.

The regulation of an alternator may be defined as the percentage rise in voltage which takes place when full non-inductive load is thrown off, the speed and field current being held constant. The regulation is also sometimes defined as the drop in voltage which takes place when, with constant field current, the full load at unity power factor is thrown on, but the first definition is the one generally used in present-day practice.

The regulation curve of an alternator will show a varying field charge with a constant terminal voltage when the machine is run at a constant speed; therefore this test consists in running the machine at full load under normal working conditions. This can only be done with machines of small output, excepting the case where two similar machines are available, when loading-back methods may be employed. When carrying out a full-load test, the alternator is belted to a shunt motor, and loaded up on a rack through step-down transformers if the machine voltage is high. It is almost unnecessary to add that the rack resistance must be equal in each phase to give a balanced load. The readings taken are those of terminal volts, armature amperes, field amperes, and also the power in watts for different values of load up to an overload point.

A loading back test is made by coupling the alternator shafts together, and also to a direct-current motor of sufficient size to supply the power lost in both machines. The efficiency of the motor being known, the power supplied to the alternators may be easily calculated from the motor input. The load current may be made to circulate between the two alternator armatures (which are short-circuited on each other through an ammeter in each phase) by weakening the field of one of them, the machine with the weaker field acting as a motor and helping to drive the other as a generator. The power factor of the load may be varied by altering the connections between the two armatures so that there is a phase difference between their e.m.f.s. When the relative position of the two armatures is such that their e.m.f.s are in opposition, the power factor will be approximately unity. When it is impossible to run a machine at full load, its regulation may be calculated from the data given by the open-circuit and short-circuit curves in the following manner: First work out the volts drop due to armature resistance for a given load, and add to it the terminal voltage on open-circuit. From the no-load saturation curve determine the exciting current corresponding to this total voltage, and add to it vectorially the field current required to give the same load with the armature short-circuited. Again, refer to the saturation curve and read off the voltage corresponding to the resultant field current, then the difference between this voltage and the terminal voltage expressed as a percentage will represent the regulation of the machine for that particular load current.

This method of determining the regulation may be used in the case of the 150kw. three-phase alternator, the calculation being worked out as follows:—

The total armature resistance $= \frac{.048}{2}$ at standard temperature, and total amperes $= 340$.

$\therefore$ The $C\,R$ drop in the armature $= \frac{.048}{2} \times 340 = 8.2$ volts.

$\therefore$ The sum of the terminal volts and $C\,R$ drop $= 440 + 8.2 = 448.2$ volts.

A reference to the saturation curve will show that the exciting current required to give this voltage $= 42.5$ amperes, also the field current required to give a load of 340 total amperes with the armature short-circuited $= 15$ amperes as given by the short-circuit curve.

Then the vector sum of these two values of exciting current $= \sqrt{42.5^2 + 15^2} = 45$ amps.

Again referring to the saturation curve, we find that the volts corresponding to this resultant field current $= 470$ volts.

$\therefore$ The regulation at full load with a constant field current =

$$\frac{470 - 440}{440} \times 100 = 6.8 \text{ per cent.}$$

The regulation of an alternator depends upon the power factor of the load, and in the case of the generator used in this example the regulation would be increased to about 20 per cent. when supplying an inductive load having a power factor of 90 per cent. If the load had a power factor slightly less than unity, say 97 per cent., with a leading current, the regulation would be zero; that is to say, there would be no rise in the terminal voltage when the load was thrown off. With low power factors and a leading current, however, the volts would fall when the load was thrown off. Good regulation in an alternator is of great importance, as this factor governs the increase or decrease in the exciting current required to supply a given load current at various power factors.

The efficiency test of an alternator is generally carried out by an indirect method, the power lost being measured directly; but in cases where it is possible to run a machine at its full load this test is always made at unity power factor—that is to say, with the current in phase with the terminal voltage. The efficiency is represented by the ratio of the power delivered to that received, the power received being equal to power delivered + losses in the machine. The losses occurring in an alternator are:

1. Armature copper loss, which varies as the square of the current.
2. Field copper loss.
3. Iron loss due to hysteresis and eddy currents, which is constant at all loads.
4. Friction loss, also constant at all loads.

The calculation of the armature copper loss has already been considered, the field loss being given by C^2R, where C = field current and R its resistance. The values of the iron and friction losses are found by actual test, as already described.

The figures given below represent the results of an efficiency test on the 150kw. three-phase alternator, which has already been taken as an example for an iron-loss test. As it is only intended to give an example, the value of the efficiency at the full-load point will only be considered.

The full-load current C of the alternator is given by $C = \frac{K}{E\sqrt{3}}$ where K = output in watts and E = terminal voltage.

$\therefore C = \frac{150{,}000}{440 \times 1.73} = 197$ amperes per phase.

But as the armature loss is calculated for values of total current, the value of $C = 197 \times \sqrt{3} = 340$ amperes. The mean armature resistance $R_a = .048\omega$ corrected to standard temperature, which is 50deg. C.

$\therefore$ The total armature resistance $= \frac{.048\omega}{2}$.

The resistance of the alternator field $= 2.155\text{w}$ at 50deg. C.

Now the armature copper loss $= \frac{C^2R}{2} = \frac{340^2 \times .048}{2} = 2774$ watts.

Field copper loss
$= \text{field current}^2 \times \text{resistance}$
$= 47^2 \times 2.155$
$= 4761$ watts.

The value of the iron loss taken at 440 volts from the saturation curve of the machine $= 2736$ watts.

Friction loss $= 1518$ watts.

$\therefore$ Total losses $= 2774 + 4761 + 2736 + 1518 = 11{,}789$ watts.

Now output $= 150{,}000$ watts.

Also input = 150,000 + 11,789
= 161,789 watts.

$$\therefore \% \text{ efficiency} = \frac{150{,}000}{161{,}789} \times 100 = 92.8 \text{ per cent.}$$

The performance curves for this machine are shown in Fig. 3.

Commercial Tests.

As regards the commercial testing of alternators, the tests generally made are those for (1) polarity, (2) temperature, (3) insulation.

Polarity.

This test is of great importance owing to the liability of mistakes being made in assembling the field coils. The effect of a reversed field coil is not so marked as in the case of a direct-current generator, because of the large number of poles in large alternators. A polarity test is made by exciting the field with a weak current, and noting the behaviour of a compass needle when passed from pole to pole.

Temperature.

A temperature test is made by running the machine on full load, but this applies only to those of small output. When it is impossible to run machines on full load, it is the custom to run them on open circuit with full-load field current and normal voltage.

The duration of a temperature test varies with different makers, but, generally speaking, a machine is run until the temperature of the various parts has reached a steady value. The temperatures taken are those of (1) armature windings, (2) armature core, (3) field windings, (4) collector rings, (5) atmosphere. It is the custom to take all temperatures with thermometers, the bulbs being placed in contact with the different parts of the machine, and covered with cotton-wool to prevent radiation of heat. Although it is standard practice to measure all temperatures with thermometers, the temperature of the armature and field windings may be determined by calculation from the increase in their resistance due to a rise in temperature. The resistance of a copper conductor increases by .428 per cent. for each degree C. rise in temperature, so that the mean temperature of the windings will be given by

$$\frac{\text{Hot resistance} - \text{Cold resistance}}{\text{Cold resistance} \times .00428}$$

but unless great care is exercised in taking the readings the results obtained are of little value.

Insulation.

As the insulation of a machine is more liable to break down when hot, an insulation test is always made at the conclusion of a temperature run. It consists in applying a high alternating voltage between the armature and field windings and the frame of a machine. In the case of low-voltage generators the testing voltage applied is generally double the working voltage; but as the factor of safety with a low-voltage winding is higher than that of a high-voltage winding, the ratio of testing voltage to the working voltage should be less for high-voltage machines to prevent the possibility of damaging the windings.

DESIGN FOR A SMALL SHUNT-WOUND MOTOR.

F. C. MASON.

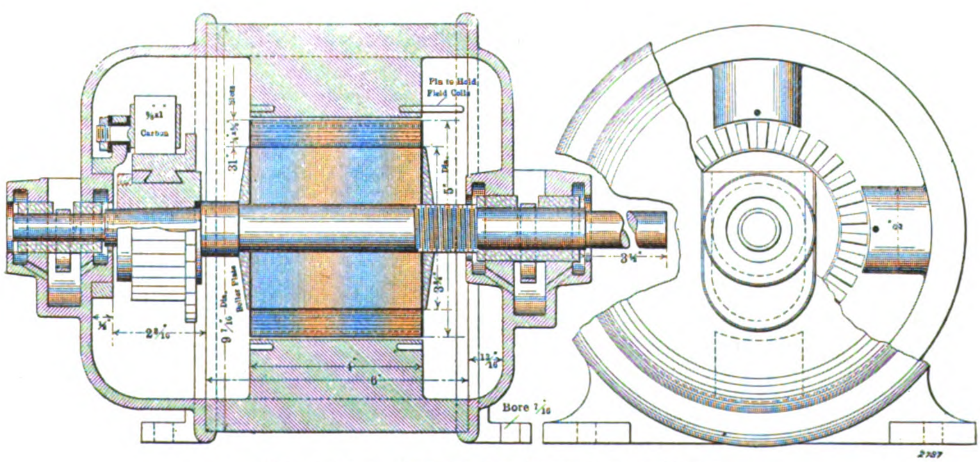
As it is not usually possible to obtain the working drawings and complete data of commercial motors, the following particulars of a 1h.p. shunt-wound, direct-current motor will probably be of interest. Many motors have been built according to the design given herewith, and they have proved to be cool running and efficient machines.

Figs. 1 and 2 show side and end elevations, respectively, of an assembled machine of the enclosed type. Figs. 3 and 4 illustrate an open type of bonnet for the commutator end. For the pulley side bonnet the same pattern may be used as is used for the enclosed type of motor, eight $1\frac{1}{4}$in. holes being afterwards bored through the sides of the bonnet. The field structure and bonnets of the machine are intended to be made of cast iron, which is easily obtained by the amateur, and is easy to machine, although the motor with a cast-iron field structure does not develop nearly so much power as one having a steel field structure, size for size. Cast iron, however, will answer for the purpose of the design. If the motor is built with a steel field structure and the winding of both the armature and field coils changed to take advantage of this superior construction, the motor will develop 50 per cent more power.

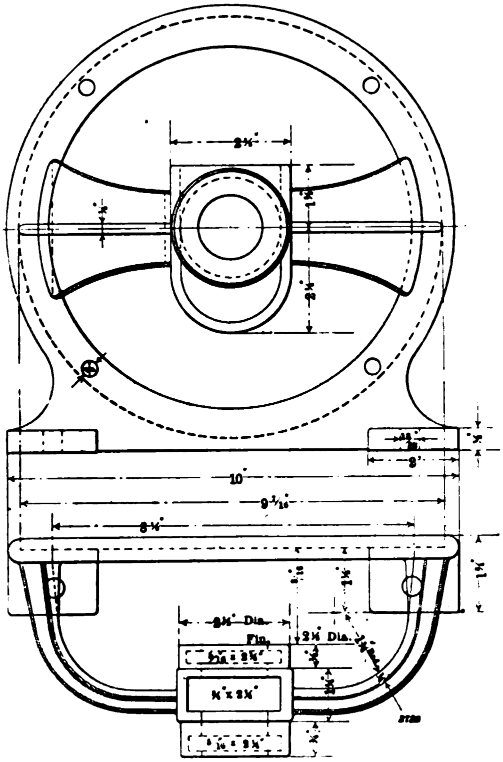
In finishing the field structure the casting is placed in a chuck and a $5\frac{1}{8}$in. boring made for the armature. One side is also faced at the same time for the bonnet. The outside of the yoke is turned off to a diameter of $9\frac{7}{16}$in. and as close up to the chuck as possible. The casting may then be reversed in the chuck and the other end turned so as to true up exactly with the part already finished.

After the boring operations have been completed the pole-piece corners should be filed off to a radius of about $\frac{1}{16}$in., so as to provide rounded corners. The bonnets may then be placed in a chuck, bored for the bearing bushing, and rough-turned for the field frame fit; they may then be placed on a true mandrel and finished to size.

The greater part of the work of building a motor is in the armature, particularly in making the discs which compose the core.



Figs. 1 and 2. Side and End Elevations of Motor.



FIGS. 3 AND 4. OPEN-TYPE BONNET.

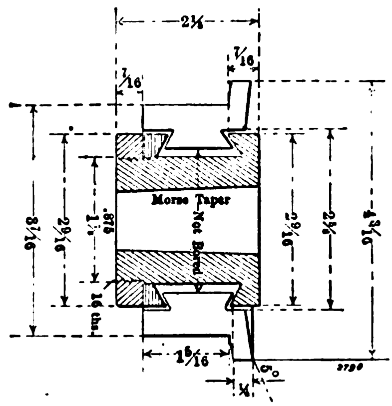


FIG. 6. COMMUTATOR.

These may be made of either charcoal iron or electrical steel. The thickness of the plate may vary from No. 20 to No. 30 gauge, and should preferably be about No. 28 gauge. If it is not possible to get the discs made to specifications by punching they may be made in the following manner: The stock should be cut into $5\frac{1}{4}$in. squares and enough of the material clamped together to give the required breadth, after which the iron may be bored and reamed for the shaft.

The discs should be clamped between two pieces of boiler plate in order to keep them flat and also to prevent the drill from tearing them to pieces when the boring operations are started. A collar mandrel 5in. in diameter, with a nut on one end to draw the collars and discs together, should be used for clamping the discs, after which they may be turned down to size.

Thirty-one slots should be milled or planed in the periphery of the discs, and the slots should be $\frac{1}{4}$in. wide by $\frac{3}{8}$in. deep. If the discs are well clamped together no burrs will result from the milling. If, however, burrs do result they should be removed. After taking the discs from the mandrel they should be washed in potash or gasoline to remove all traces of oil, and then shellacked on each side and dried. In the engraving the discs are shown key-seated. This, however, is not necessary, but facilitates assembling.

The shaft is shown in detail in Fig. 5. This may be made of machine steel, tool steel, or any other suitable material, but the writer prefers tool steel. It is advisable first to rough-turn the shaft and to finish it only where the discs go on. The headers for clamping the discs may be made of boiler plate. When assembling the core, fibre discs $\frac{1}{16}$in. thick should be placed on each end between the header and the metal discs, and being of the same diameter these may be turned out at the same time as the metal. In assembling the discs the slots may be kept parallel by inserting a piece of $\frac{1}{4}$in. material in one slot. The core may then be screwed up tight, heated slightly, and allowed to cool. The heating serves to set

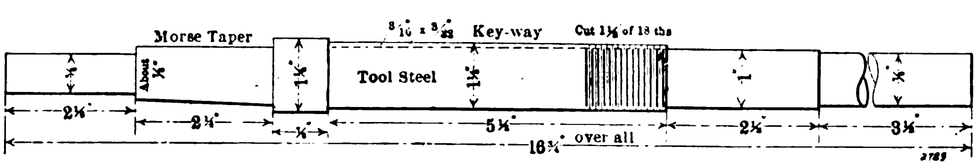


FIG. 5. DETAILS OF SHAFT.

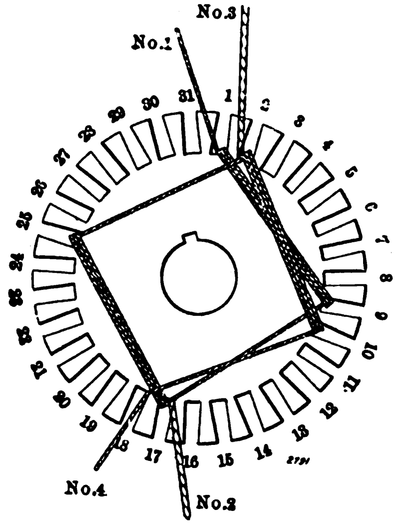


FIG. 7. ARMATURE WINDING.

the shellac and freeze it to the shaft so that there will be no possibility of the core moving while the armature is under torque, even without the key. When the armature core has cooled sufficiently the turning down of the shaft may be completed.

Fig. 6 shows a sectional view of the com mutator. The brushing may be made of cast iron or brass. The copper segments for the commutator must be absolutely iusulated from each other as well as from the brushing or shell. If it is not desirable to build the commutator, a complete commutator may be purchased. There are two kinds of micanite used for commutators; the harder grade is used for insulating the copper segments and the semi-flexible grade for making the washers and rings for insulating the segments from the shell. The semi-flexible micanite is made in sheets and does not differ in appearance from the hard micanite. By applying heat, however, it can be formed into the required shapes by using the shell for the mould.

In assembling the copper segments a machine-steel ring about 4½in. inside diameter by 5½in. outside diameter and 1½in. wide, with as many set screws as can be conveniently placed on it, should be used. Thirty-one pieces of hard micanite 1¼in. by 1¾in. will be necessary,

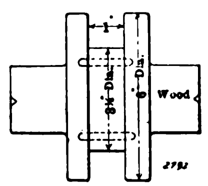


FIG. 8. BOBBIN.

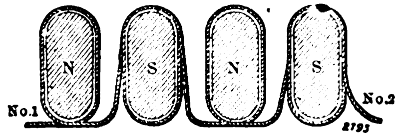
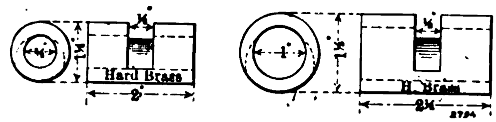


FIG. 9. FIELD COILS.

and this micanite should preferably be $\frac{1}{32}$in. thick. The copper segments and micanite should be assembled inside the ring, each ring and segment being shellacked and forced together with the set screws, care being exercised to keep the commutator circular by repeated calipering.

When the assembling of the commutator is completed it should be baked until the shellac becomes hard. After baking the commutator should be placed in a lathe and the inside finished to fit the shell, as shown in Fig. 6. The micanite used to insulate the commutator segments from the shell



FIGS. 10 AND 11. BEARINGS.

should be $\frac{1}{16}$in. thick and should be carefully fitted in. The whole may then be tightened together by the nut and the end of the shell. The ring may now be removed from the outside of the commutator, and the commutator given a rough turn. A slot $\frac{1}{32}$in. wide by $\frac{1}{8}$in. deep should be sawed in the ear of each commutating segment for the reception of the armature coil terminals. The winding specified for the armature will give the machine a speed of 1200r.p.m. at 115 volts. If connected to a 220-volt circuit the speed will be about 2000r.p.m.

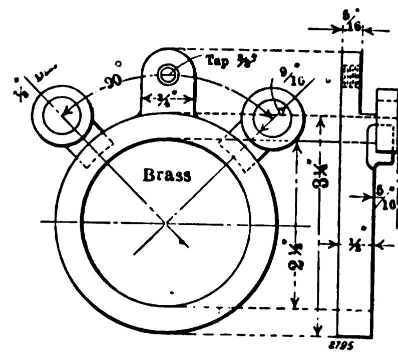
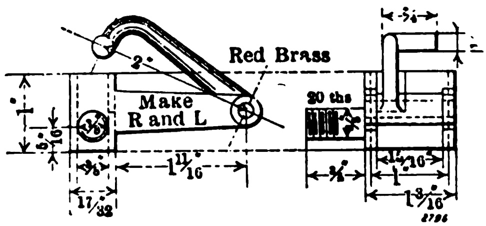


FIG. 12. BRUSH YOKE.



FIGS. 13 AND 14. BRUSH HOLDER.

Although the armature could easily be fitted with form-wound coils, the amateur will probably find it easier to wind covered magnet wire. Fig. 7 gives a schematic winding diagram. Small pieces of oiled linen should be placed around the teeth between the slots, in order to protect the insulation on the wire from rupture. Starting at slot No. 1, wind to slot No. 9, 25 turns of wire, bringing the terminal across to slot No. 17 and carrying out a twisted loop for terminal No. 2. Then wind from slot No. 17 to slot No. 25, twenty-five turns of wire, bring the terminal up to slot No. 2 and twist a loop as before for terminal No. 3. Next wind from slot No. 2 to slot No. 10 in like manner, bringing terminal No. 4 out at slot No. 18, and so on. Place under all layers of wire, or where one layer crosses another, a piece of thin cotton or oiled linen. Continuing the winding as described, when the fifty turns are in each slot the last terminal will connect with terminal No. 1. This gives a continuous winding with no chance whatever for the connections being wrong when the winding operations are finished.

When the armature is completely wound three bands of retaining wire should be placed round the core. The bands may be made of No. 24 hard brass wire, and should be wound on a thin layer of mica, in order to insulate them from the core and winding. These bands are intended to keep the coils in place when the machine is in operation.

The commutator should be provided with a pin key in order to prevent any possible chance of its moving. The segments should be parallel with the slots in the core, and the armature terminals brought out straight and soldered in the ears of the commutator segments. Good solder should be used, and the soldering copper should be hot enough to cause the solder to flow freely so as to produce a first-class joint between the segments and terminals.

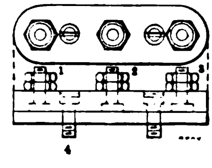
Fig. 8 shows a wooden bobbin for convenience in winding the four field coils. The coils should be wound with exactly 1200 turns of No. 25 single cotton covered magnet wire, in order to obtain the best results. Common lamp flexible cord may be used for the terminals, a soldered and taped connection being employed. The field coil may then be wound with one layer of cotton tape and then formed to fit the poles, after which another layer of tape may be applied. Fig. 9 shows a development of the field coils and illustrates the method of connecting the coils together, so that no further explanation is necessary.

The bearings, Figs. 10 and 11, should be made of phosphor bronze, bored and rough-turned. Each bearing may then be placed in a chuck eccentrically, and a cut taken for the oil rings. A half-round groove should be cut in the bottom side of the bearing for the oil pocket. The outside of the bearing may then be finished to an easy driving fit in the bonnets.

Fig. 12 shows the brush yoke, which may be made of cast iron or brass, but preferably of the latter material. The yoke shown is intended for a motor of the enclosed type. The ear in the middle at the top is provided for locking the yoke to the bonnet after it has been set in its proper position. For a motor of the open type this ear may be cut off and a $\frac{5}{16}$ in. set screw substituted for the purpose of locking the brush yoke to the hub of the bonnet on which it is placed.

Figs. 13 and 14 show the brush-holder. The holder may be made of brass, and right and left patterns should be made. The arm for holding the brush against the commutator should be provided with a coil spring around its hub, one end of which is connected to the arm and the other end to the brush-holder proper.

Fig. 15 shows a connection block, which may be placed in the field structure or bonnet. The screws 1, 2, and 3 are for the terminals, and the screws 4 and 5 are for the purpose of fastening the block to the frame. Connect terminal No. 1 of the field coils and the lead from one brush-holder to bind-



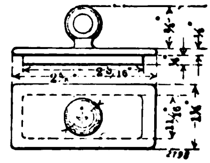


FIG. 15. TERMINAL BLOCK. FIG. 16. OIL WELL COVER.

ing-post No. 1. Field terminal No. 2 should be connected to binding-post No. 2, and the lead from the remaining brush-holder should be connected to binding-post No. 3. These three permanent connections should all be made under the nut next to the fibre. The outside nut is for the purpose of providing a terminal for the line and starting-box. The connecting blocks should be made of hard fibre, and brass screws should be used, as steel screws corrode easily and make a very poor electrical connection. The dimensions and form of the brass cover for the oil wells are given in Fig. 16. All the necessary dimensions for building the motor are given on the drawings.—*Elec. World.*

A Swiss 15,000-Volt Single-Phase Traction System.

For the last few years Swiss engineers have been experimenting with single-phase traction, and particularly with that of the Oerlikon system. As early as 1901 the Oerlikon Company made the proposition to electrify the Seebach-Wettingen line. Before receiving their franchise the company made experiments on a line between Oerlikon and Seebach, and later continued the line to Affoltern. To hinder matters there is a law prohibiting 15,000-volt lines from being run alongside railway tracks and telephone systems.

In the summer of 1904 the Oerlikon Company had in operation locomotive No. 1 running at 5000 volts 50 periods. Because of the difficulties experienced in the operation of No. 1 the Company built another, No. 2, to operate at 15,000 volts 15 periods. This locomotive was put in operation in November, 1905, and the results of the experiments carried on were such that locomotive No. 1 was reconstructed on the lines of No. 2. By the end of 1907 the whole line from Seebach to Wettingen, twelve miles, was put in operation, jointly by the Oerlikon Company and Siemens-Schuckert Werke.

The section from Seebach to Regensdorf, about four miles, is equipped with the Oerlikon trolley, and from Regensdorf to Wettingen, about eight miles, with the Siemens-Schuckert trolley. There are at present three locomotives in operation, which are equipped with both systems, so that they can operate on the two systems.

There are seven stations situated along the line, and no gradients of any account. The smallest radius of the track is 980ft. The rails are used as the return circuit.

Power is supplied from the plant of the Oerlikon Company at Oerlikon, for which purpose an additional 700kw. turbo-generator was installed. The steam turbine is of the three-stage, direct-acting type, and is placed with its generator on a common bed-plate. The turbine is connected to a revolving-field alternator by a needle coupling, and is provided with a jet condenser located in the basement. At the end of the generating room there is a switchboard with three panels, equipped with the necessary instruments for throwing the current on to the transformer station, Seebach-Wettingen, or for manufacturing purposes. As all the existing equipment was for 230 volts and fifty periods, the generator adopted for this additional plant has similar characteristics.

The experiments were carried on at fifty periods, which, however, proved unsatisfactory, and fifteen periods was adopted. The energy received from the power-house as three-phase, fifty-period current is transformed through motor-generator sets. The substation erected near the power-house has the following equipment: Two motor-generator sets of 700kw. and 500kw. capacity. Each consists of a fourteen pole, 230-volt, fifty-period synchronous motor with 100-volt excitation coupled on one side to a four-pole, 700-volt, fourteen to fifteen period generator with 100-volt excitation. On the other end is coupled a 750 to 85c-volt, 350amp., direct-current generator, which operates in connection with a storage battery.

The fields of the generators are regulated by two Thury regulators. When the generators are operating in parallel the regulators are mechanically interconnected by gearing and shafting.

The exciter current for the synchronous motors is furnished by a 50h.p. 50-period 100-120-volt motor-generator set.

A 120h.p. booster outfit operates in connection with the storage battery. The booster has two commutators which, when they feed the storage battery, operate in series, but when operating under normal conditions are switched in parallel. The booster is operated by a three-phase induc-

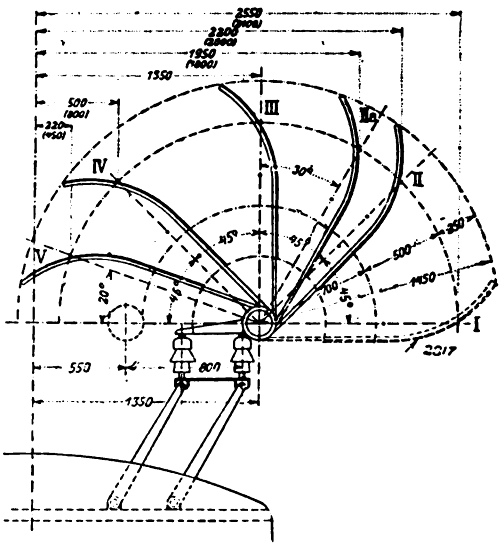


FIG. 1. THE OERLIKON COLLECTOR ARM.

tion motor fed from the three-phase power-house supply. The regulation is done in two ways, either by a Thury regulator receiving current from the trolley line or by means of a Siemens-Schuckert converter with a differential excitation operated by a chain drive from the shaft of the 700kw. motor-generator set. The converter furnishes 30amp. at 38 volts.

The storage battery, located in a separate building, consists of 375 cells and has a capacity of 592 ampere-hours. For a period of five minutes it can give 1200amp. or 1800amp. for one minute.

On one end of the substation is the transformer compartment, in which are installed four 250kw. single-phase transformers to step up the 700 volts from the motor-generator sets to 15,000 volts for the trolley. There is also a 450kw. three-phase transformer receiving 30,000 volts from Hochfelden, stepping it down to 210 volts for the motor-generators, in case the power-house supply should fail.

The Oerlikon trolley system is installed from Oerlikon to Seebach, where it joins the main line to Regensdorf. At Seebach the wire is suspended by catenary construction from bridges with eight spans of 165ft. and 200ft. The trolley is hung 16½ft. above the rail by steel wires about 23ft. apart. From Seebach to Regensdorf the trolley wire is carried on poles at the side of the track by means of semi-rigid construction mounted on cast-iron caps fastened to insulators which are carried on the brackets of the poles. The line is divided up into several sections. At the end of each section is a horn section switch carried on a steel pole, which also carries a semaphore. The switch operates by hand or automatically from the railway station, for which purpose a pilot wire is carried on the wooden poles.

The Oerlikon collector is placed on top and to one side of the locomotive. It consists of an automatic adjustable arm mounted on the top of a four-bar linkage. By referring to the illustration Fig. 1 it will be seen that the arm may occupy any position from I to V for a fixed position of the linkage. From positions I to V gives a sweep of 7.5ft. By shifting the linkage an additional 2.5ft. is gained. The trolley may hang directly overhead on 8ft. to one side of the centre line and the current may be drawn from the top, side or bottom of the trolley wire, thus securing great flexibility, for which the system is noted. Under ordinary conditions the trolley is at the side of the track to facilitate erection and repairs. The collecting arm is held in contact with the trolley by a spring device which may be operated by hand or electro-pneumatically. When not in operation the collecting arm is held flat on top of the car.

The arms are made of seamless, drawn steel tubes about 7.5ft. long and slightly bent at one end. There are two such arms to one collecting device.

The Siemens-Schuckert trolley system starts at Regensdorf, ends at Wettingen, and overlaps the Oerlikon trolleys for a distance of 1300ft., so that the change from one system to the other is made without interruption. The trolley wire is suspended by catenary construction 19.5ft. above the rails. Between Otelfingen and Wuerenlos, for a distance of 0.6 mile, the trolley is only 15ft. above the rail. The catenary wire, a steel cable 35 square millimetres, rests on cast-iron caps carried on insulators, and carries an auxiliary catenary by supension wires 19.7ft. apart. From the auxiliary catenary the main trolley is hung by clamps from 9ft. to 10ft. apart. On the main line, the trolley is carried on side poles, while at stations it is carried on pairs of channels spanning, in some cases, seven tracks. The overhead trolley line, with its complete catenary, is divided up

into sections in order to keep them taut. The spans, in the sections where the wires overlap, are 375ft. long. For a distance of 35ft. or 45ft., in the middle of such a span, the wires are parallel and about 5in. apart. The ends of each section are led from the centre of the track to side poles, where they are provided with a tension arrangement. The weights in the above arrangement are 600lb.; as the sheaves have a ratio of one to two, there is a continuous pull on the line of 1200lb. The sections are dead-ended at one end.

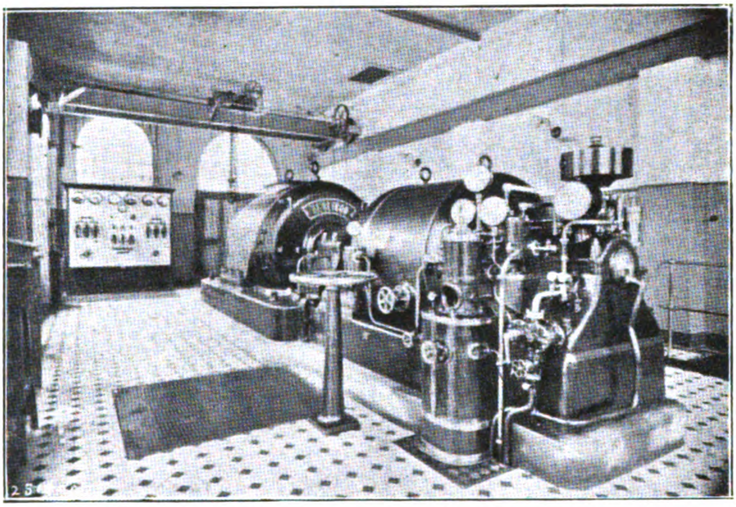


FIG. 2. INTERIOR OF THE GENERATING STATION.

A tension arrangement is located at each station and midway between stations, so that the sections are about one mile long.

The Siemens-Schuckert collecting device is a sliding-bow pantograph arrangement. The contact piece is a removable U-shaped piece of aluminium pressed against the trolley by flat springs. The locomotives No. 1 and No. 2, of the Oerlikon make, have only one pantograph, while No. 3, of the Siemens-Schuckert make, has two.

The poles on the line are placed between 160ft. and 170ft. apart. In some cases, for experimental purposes, the span was lengthened to 330ft.

At sidings and locomotive sheds the trolley wire is provided with circuit-breakers, so that power may be supplied to the sidings when necessary.

The rails are used as the return circuit, and are well bonded. Every mile and a quarter they are specially grounded by large copper plates.

From Wettingen to Seebach there are seven stations along the line, on the average about two miles apart. The section switches are controlled from the stations, and the keys to the switches are in the possession of the station master. At Kempfhof, owing to heavy street traffic, the sliding gates are electro-mechanically connected to the overhead trolley, so that when the trolley is alive the gates are closed. This was done at the request of the public service commission.

There are at present three locomotives in operation. Locomotive No. 1 was built in 1904 for experimental purposes and was known as "the converter locomotive." It was later changed over into a single-phase locomotive. The converter was rated on the alternating-current side as a 650h.p., 700-volt, asynchronous motor, and on the direct-current side as a 400kw., 600-volt generator with a speed of 1000r.p.m. Overhanging one end of the driving shaft was a 150-volt, direct-current generator which was connected to the direct-current side of the converter. This generator acted as a booster, so that various voltages could be applied to the driving motors, which were shunt wound. The line voltage was stepped down from 15,000 to 700 by two 250-kilovolt-ampere air-cooled transformers. It was found out during experiments that it would be advisable to change the equipment to single-phase, fifteen periods, because, owing to the peculiar operating conditions (the frequent stops during which time the converter had to remain in operation), the current consumption was comparatively high, although otherwise the equipment was very satisfactory and highly efficient.

The body of No. 1 rests on two four-wheel swivel trucks, each having a 200h.p. motor mounted between the axles. There is no king pin; the theoretical swivelling

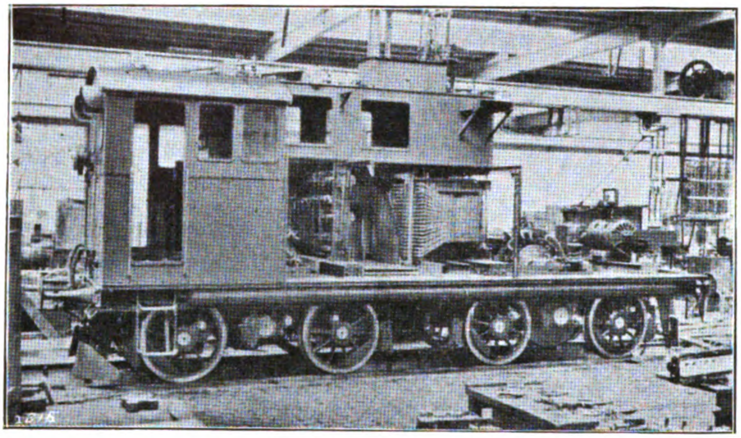


FIG 3. LOCOMOTIVE NO. 1 AS REMODELLED.

point is controlled by levers. The motor is geared to a separate driving shaft from which the drivers are operated by means of a crank-pin and connecting rod. The brakes, one for each wheel, are operated pneumatically or by hand. The total weight has been reduced from 48 to 40 tons, due to change of equipment.

The body of locomotive No. 2 is built on the same lines as No. 1, except that it has a cab at each end for the motorman and weighs 42 tons. It is equipped similarly to locomotive No. 1 with an Oerlikon rod collector and a Siemens pantograph collector, both having hand and electro-pneumatic control.

The current is led from the trolley to four transformers connected in series-parallel. Each transformer group has a capacity of 250 kilo-volt-amperes. They are wound for 15,000 to 700-volt transformation, are air-cooled, and are located in the centre of the car. In the cabs, at each end, are two controllers, one for controlling the motors, the other for controlling the transformer taps.

The motors are series wound, with interpoles, of 250h.p. capacity each. They make 650r.p.m. normally and 1000 maximum. With a gear ratio of 1 to 3.08 and drivers of 39.5in., a speed of about thirty-six miles an hour is attained. On gradients of 0.8 to 1 per cent. a speed of twenty-four miles per hour is attained, while on short stretches of 1.2 per cent. the same speed can be maintained. These values are calculated for a train weighing 250 metric tons. Tests have shown that the motors can operate just as well on 25 periods.

Each locomotive has a 6h.p. motor-driven air-compressor operating at 140 volts. The compressors supply air at pressures between 75lb. and 105lb. The operation is automatically controlled by the air pressure. The air is used for operating the various apparatus, such as bow collectors, &c. Current for these motors is drawn from special taps on the transformer, which also has taps for lighting and heating.

Locomotive No. 3 rests on two six-wheel trucks; the king pins are 19.7ft.

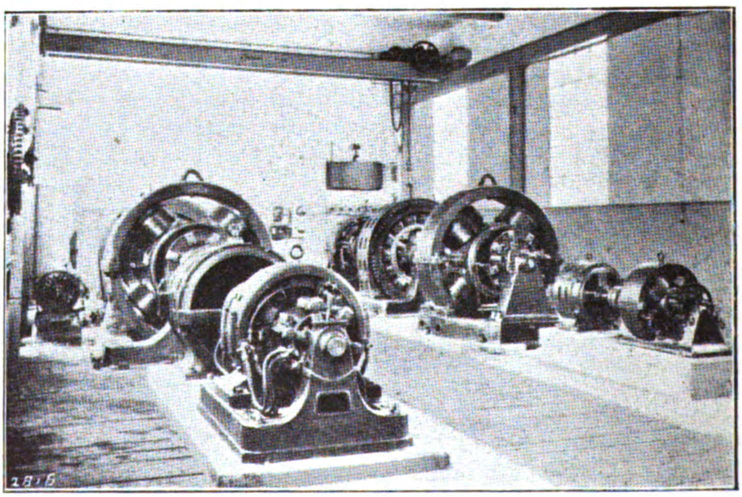


FIG. 4. INTERIOR OF SUB-STATION.

apart. The trucks are of the same design as those of the famous Marienfeld-Zossen experimental locomotives, built by Siemens-Schuckert-Werke, who also supplied locomotive No. 3. This locomotive is designed for a six-motor equipment, although at present only four are mounted. Each motor has a capacity of 225 horse-power, eight poles, artificially cooled and geared to the drivers through a gearing with a ratio of one to 3.72. The length over all is 45ft. The car is equipped with two Siemens-Schuckert collectors and a pair of Oerlikon collectors. The two transformers, of 500kw. capacity each, are located in iron compartments with removable doors, and are wound for 15,000, to 288, 330 and 378-volt transformation and are oil-cooled. On the high-tension side there are overload circuit-breakers, operated automatically or by hand. There is provision in the high tension compartment for the three motors of each truck, three contactors for speed control, and two for controlling direction of current. The contactor compartments are placed in three tiers.

This locomotive, equipped with 4 motors, has a weight of 68 tons, and a tractive effort of 10,300lb. for an hour; the maximum is 17,200lb. When equipped with 6 motors the weight is 75 tons and the tractive effort 15,600lb. for one hour; the maximum, 25,740lb.

On the experimental section of this line, in 1904, for a distance of 2500ft., the 15,000-volt, 50-period line ran parallel to the telephone systems. When the high-tension system was operated at 50 periods, the operation of the telephone lines was impossible. The trouble was remedied by changing the frequency from 50 to 15 periods. Experiments show that even 30 periods has little or no effect. The voltage, 15,000, remained the same. Oscillograms of the motor show that the current and voltage curves, although sinuous in character, are very ragged. This trouble was corrected by changing the slot spacing and putting the poles on the skew. The former trouble was experienced on locomotive No. 1, while the latter appeared on No. 2 after 15 periods was adopted.

It might be of interest to state that between December 3rd and January 6th only three interruptions occurred: one insulator broke, a trolley wire slipped out of its end clamp, and a short-circuit in a sub-station. Encouraged by the success of this road the Swiss engineers propose to build 3500h.p. to 4000h.p. locomotives for further electrification of other trunk lines.—*Elec. Rev., N. Y.*

Gas-Electric Plant Test.

At a recent meeting of the American Institute of Electrical Engineers, Mr. J. R. Bibbins reported the results of a 30-day test on the generating station equipment of the Richmond Works of the American Locomotive Company, of Richmond, Va. The equipment consists of a 23.5in. by 33.0in. horizontal, tandem, gas engine with a direct connected direct-current generator operating on producer gas obtained from a pair of 9ft. (shells) bituminous producers. The generator supplies energy to motors and lamps in the locomotive shops, the load being fairly constant. The accompanying table records the general results of the test:—

GENERAL RESULTS OF TEST.

	Load.		
	Full.	¾	½
Length of run, hours	223	125	136
Average load, kw...	312.3	228.3	159.6
Average load, computed h.p.	455.0	333.0	238.0
Load, per cent. engine rating	91.0	67.6	47.5
Load, per cent. generator rating	104.0	77.2	53.2
Coal gasified, lb.	115,289	54,143	47,775
Coal gasified, per hour ..	517.0	433.0	351.0
Output, kw.-hour	69,650	28,540	21,710
Lb. coal per kw.-hour.. ..	1.654	1.697	2.20
Lb. coal per kw.-hour guaranteed	1.93	2.10	2.64
Lb. coal per boiler, h.p.-hour	1.14	1.31	1.56
Average heat value of coal, b.t.u.	14,392	14,392	14,392
B.t.u. per kw.-hour	23,700	27,280	31,650
B.t.u. per boiler h.p.-hour..	16,415	18,710	21,670
Per cent. thermal efficiency, brake	15.51	13.6	11.75
Per cent. thermal efficiency, elec.	14.35	12.65	10.78

Coal.—Pocahontas run of mine; avg. heat value dry sample, 14,703 b.t.u. per lb.; as fired, 14,392; volatile matter, 22.8 per cent.; ash, 4.5 per cent.; sulphur, 1 per cent.

Test.—August 12, 7 a.m., to September 7, 12 m.

In comparing the cost of producing electrical energy in the above plant with an equivalent steam-turbine plant for the same duty, the author stated that at the price of coal prevailing in Richmond, 11s. 3d. ($2.70) per ton, the gas plant shows a 13 per cent. gain over steam at full load and 5 per cent. at half load. The estimates include interest, &c., on the cost of the complete gas plant at £28 15s. ($138) per kw., and of the steam plant at £20 16s. ($100) per kw.

ELECTRIFICATION OF THE ST. CLAIR RAILWAY TUNNEL, CANADA.

J. J. BELL, M.A.

IN the year 1890 the St. Clair Tunnel, between Sarnia, Canada, and Port Huron, Michigan, was opened for railway traffic. Previous to that time great inconvenience was caused, and frequent interruption took place in the train service on the Grand Trunk Railway, especially during the winter, as all the traffic which crosses the St. Clair River had to be taken care of by ferry. The work of constructing the tunnel involved some unique features in engineering, but it was carried to successful completion, and has well served the purpose for which it was built.

A new chapter is now to be written in the history of this great work. Being a single-track tunnel, its capacity under existing conditions had been reached. An average of 30,000 freight cars per month passed through, which meant more than sixty trains per day, besides twenty passenger trains. The gases generated by the combustion of coal in the locomotives were a constant source of danger, and had resulted in the loss of a number of lives, the most serious accident having occurred in 1904, when six men were asphyxiated. The Canadian Railway Commission in view of these facts issued an order that the tunnel must be operated by electricity, and the work of installation

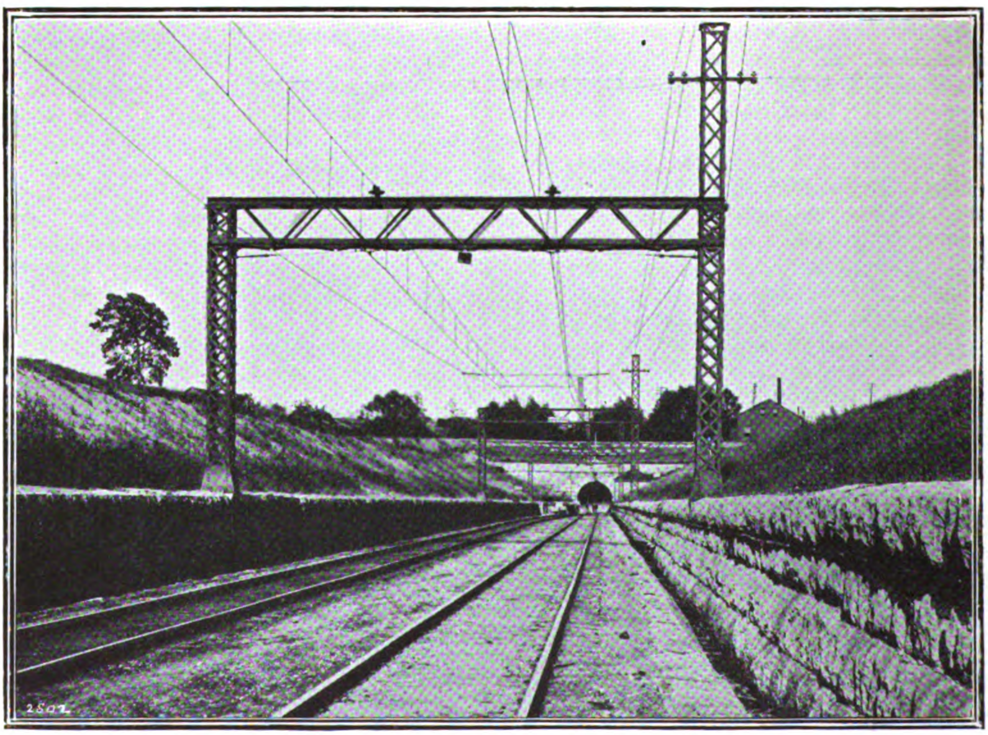


FIG. 1. PORTAL OF ST. CLAIR TUNNEL, SHOWING OPEN-CUT GRADIENT.

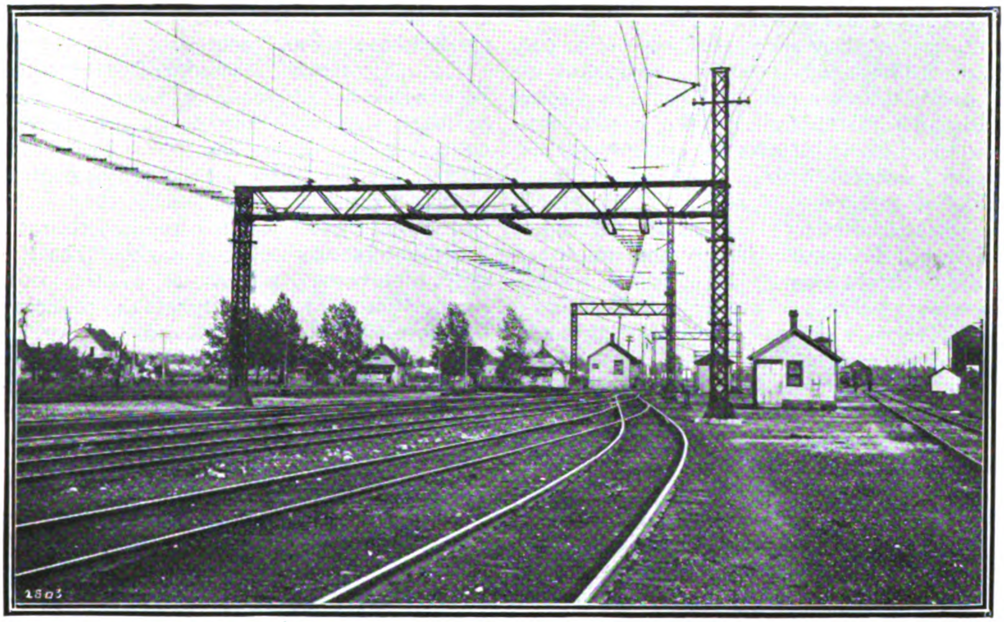


FIG. 2. BRIDGE OVER TRACK, SUPPORTING TROLLEY WIRES, ST. CLAIR TUNNEL.

has been in progress for the past year. The complete electrical system is now in operation, though at the time of writing it has not yet been formally handed over to the Tunnel Company; the Westinghouse Electric Company, of Pittsburg, Pa., which had the contract for the entire work, being bound to operate it for three months before handing it over.

The equipment represents the latest development in electric railway practice. The distinguishing feature is the single-phase locomotives. A pantagraph trolley is used instead of a third rail. A charged third rail at passenger stations and in terminal yards is a constant source of danger; by the use of a high-voltage trolley and single-phase locomotive this is avoided. A similar system was recently inaugurated on the New York, New Haven and Hartford Railway, where it has given every satisfaction.

The tunnel division of the Grand Trunk, which comes under the new operating conditions, is approximately four miles long. It includes the passenger stations at Sarnia and Port Huron, and the necessary yards. The stations are three miles apart, each being back one mile from the river. The depth of the St. Clair means a low-level tunnel, and therefore severe operating conditions. Every train must descend and then ascend 100ft. within $2\frac{1}{4}$ miles. Approximately one mile of this track on each side of the river has a 2 per cent. gradient, the remaining quarter of a mile being on the level under the river. The tunnel proper is 6032ft. long, more than half a mile of the approach at either end being open cut. These cuts each involve the drainage of some ten acres of embankment. A pumping plant at each portal takes care of this. The steam pumps hitherto in use have been replaced by motor-driven pumps. The leakage in the tunnel is insignificant; two small air-driven pumps have taken care of this, and the condensation from the exhaust steam of the locomotives. These seepage pumps have also been replaced by motor-driven pumps.

The steam locomotive system hitherto in use required the service of four locomotives, which, with tender loaded, weighed 117 tons, with only 87 tons weight on the drivers. These locomotives could generally get up the tunnel grades with a 750 ton train, but the speed at the summit scarcely reached five miles an hour. The electric locomotives, five in number, weigh 65 tons each, with all the weight on the drivers. Each has a nominal capacity of 750h.p., but they will usually be operated in pairs. Each pair can exert the 50,000lb. drawbar pull neces-

sary to draw a 1000-ton train up the 2 per cent. grade at a speed of 12 miles per hour. They can exert a maximum of 85,000lb. drawbar pull, and have, in a test, started a 1000-ton train on the 2 per cent. grade and carried it over the summit. This means heavier trains and higher speed, and therefore increased capacity. The running time from summit to summit for passenger trains will be from eight to nine minutes, and for freight trains from eleven to twelve minutes. In a twenty-four hour test made on March 21, 1486 cars were passed through the tunnel with two motors.

With the electric installation air brakes can be used in operating the trains, which was not permissible under the old system. The breaking in two of a train with air brakes means the automatic application of the brakes. An emergency application of brakes in the tunnel was a serious matter, as the time required to release the brakes meant holding a steam locomotive for a period exceeding the danger limit. With electric locomotives there are no gases, therefore they can be held in the tunnel as long as desired. With air brakes a higher speed is allowable than when hand brakes are used, and thus greater safety and increased capacity are secured.

Each locomotive is equipped with three Westinghouse single-phase motors. The auxiliary apparatus consists of the current collecting and controlling gear. For actual operation there is simply the motor control handle and the air brake handle, the former corresponding to a steam locomotive throttle. The motors operate at a low voltage; the only high-voltage apparatus in the cab, besides the main line switch, is the reducing transformer. Both switch and transformer are so completely isolated that there is no danger from the high voltage. The operation of an electric locomotive is simpler than that of a steam locomotive, as the driver has merely to apply the power, and is not concerned in its production.

Power is taken from the overhead trolley at a pressure of 3300 volts. A high class of overhead construction is required. The trolley supports are similar to those used for signal bridges. There are 57 bridges, some 250ft. long, spanning nine tracks. The bridges are tied together with steel guy cables. The trolley is kept practically level by suspending it at 12ft. intervals from a

FIG. 3. ELECTRIC LOCOMOTIVE, ST. CLAIR TUNNEL RAILWAY.

steel messenger cable. The trolleys are tied together with cross guys to prevent vibration in the wind. Isolating switches are inserted which will enable any trouble to be localized and repairs made without interrupting the train service. Power is fed into the overhead system by a feeder that taps the trolleys in the tunnel almost directly under the power station. The current returns through the track rails to a feeder that enters the tunnel at the same point as the trolley feeder. Single-phase current is used.

Besides the trolley and rail feeders there are cables for tunnel, yard, station, and roundhouse lights, and for the portal pumps and roundhouse motors; these cables enter the tunnel at the same point as the trolley and rail feeders. They lie in ducts encased in concrete. The interior of the tunnel, begrimed with smoke from the steam locomotives, is to be cleaned and whitewashed, and lighted with incandescent lamps, 12½ft. apart. Two tracks for passenger business, and five for freight, on the Canada side, will be operated by electricity, and four for passenger and four for freight on the United States side.

The power-generating station stands on the bank of the river, on the Michigan side, directly over the tunnel. It is 100ft. square, the office front 20ft. high, the main west wall 40ft. high, and the river wall 60ft. high. The building is of concrete, brick and steel construction. It has a concrete stack, which rises 175ft. above the level of the river. The boiler room is lined with white brick, the dynamo room also with white brick, with panels of enamelled brick. A fireproof wall separates the boiler and dynamo rooms.

The boiler room is provided with a concrete coal bunker, which holds enough fuel for ten days. The coal is dumped from the cars into a hopper under the power-house siding. It is crushed, elevated and distributed to an overhead bunker by a belt-conveyer, whence it is distributed to the hoppers of automatic stokers. The boilers are of extra capacity, to provide for any sudden load that the tunnel service may require. A feature of the boiler equipment is a separately fired superheater. This is a modern arrangement, introduced with turbine practice. The usual feed water-heaters are provided. The feed pumps—as, in fact, the whole equipment—are in duplicate. A distinctive feature is the turbo groups. Either unit can handle the entire tunnel system and consists of a 1800h.p. Westinghouse-Parsons steam turbine driving a 1250kw. generator operating at a normal speed of 1500r.p.m. The turbine supply is superheated steam at 200lb. pressure, and each operates in conjunction with a barometric condensing plant. The electric generators, exciters, and switch gear are of the usual standard Westinghouse types. The whole design of the power house and its equipment is simple and of the latest pattern.

The grounds in which the power house stands will be terraced and turfed, laid out with flower beds and planted with trees, the whole presenting a neat and pleasing appearance.

The cost of the electrical installation is understood to be about half a million dollars besides some additional expenditure from the overlapping of service during the transition. The original cost of the tunnel was about $2,700,000. The change has been effected with a minimum of interruption to traffic, much of the work in the tunnel being done at night.

Every precaution has been taken to safeguard employees and others in the operation of the plant, and elaborate instructions have been issued to all identified with work in the yards, tunnel and trains.

Round-house accommodation has been provided at the Sarnia end, where the electric locomotives will be housed and necessary repairs and inspections made.

The "Entz" Carbon Regulator.

THE problem of how best to deal with a widely varying load is one upon which it is not easy to generalise. The circumstances surrounding each individual case require careful investigation, for not only have the variations of the load to be considered, but the time element is often the determining factor. Where the fluctuations rapidly follow each other, are comparatively small in extent, and do not exceed the overload capacity of the generating plant, it is sometimes sufficient to meet the conditions with an over-compounded steam generator. If, however, on any system of power distribution there are connected a number of motors dealing intermittently with a comparatively heavy load, the installation of a battery and booster would offer the following advantages:—

1. The saving of a considerable amount in the first cost of the generating plant.
2. Constant operation of the generating plant at a steady load.
3. Saving in feeders.

It is a *sine quâ non* that the booster employed on a rapidly varying load should be instantly reversible. The "Entz" Carbon Regulator fulfils this condition in a remarkably simple way.

The regulator itself consists of two sets of piles of carbon discs, over which is a balanced lever pivoted between the two sets. From one end of this lever is freely suspended the soft iron core of a solenoid which carries the entire generator load, while to the other end is attached a helical spring, whose tension may be adjusted by hand to counter-balance the pull of the solenoid at any desired load on the machines. Slight variations of load above or below this amount will cause changes in pressure on the carbon piles, resulting in wide variations in their contact resistance. Advantage is taken of this resistance variation to control the field excitation of the battery booster, usually through the intermediary of a small exciter, between whose fields and the carbon piles connections are made similar to those of a Wheatstone bridge, the current in the exciter fields varying in direction and amount with changes in the pressure on the carbon piles.

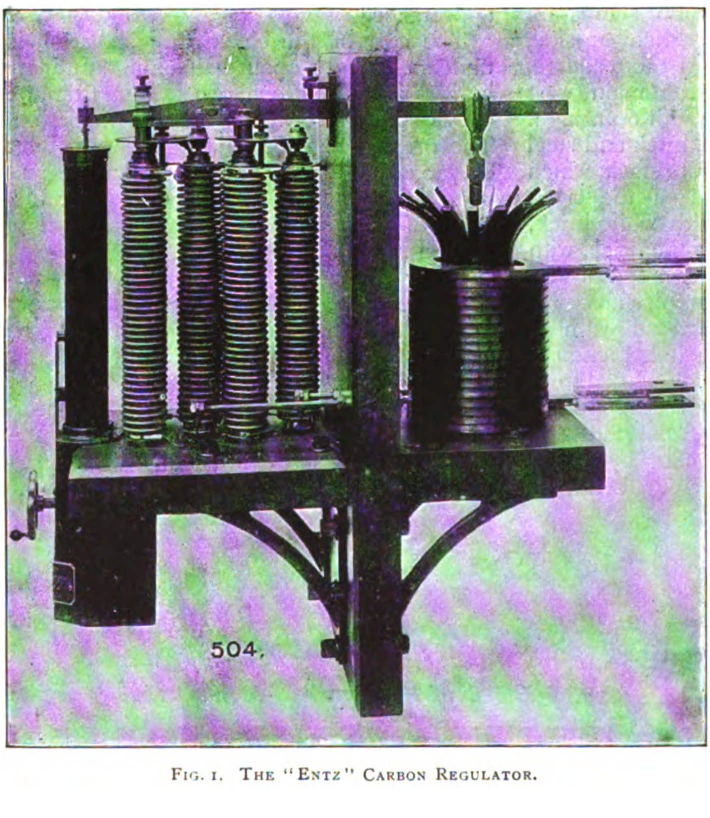


FIG. 1. THE "ENTZ" CARBON REGULATOR.

The arrangement of connections is shown diagrammatically in Fig. 2. It will be seen that the + bus bar is divided, and an actuating coil carrying the generator current is inserted. The battery is connected across the main bus bars in series with the armature of the booster, which has a single set of field coils separately excited. The exciter may be mounted on the booster shaft or driven by a separate motor or other means. It will be noted that the construction of the booster is greatly simplified by the absence of the series field coils used in boosters of the differential type.

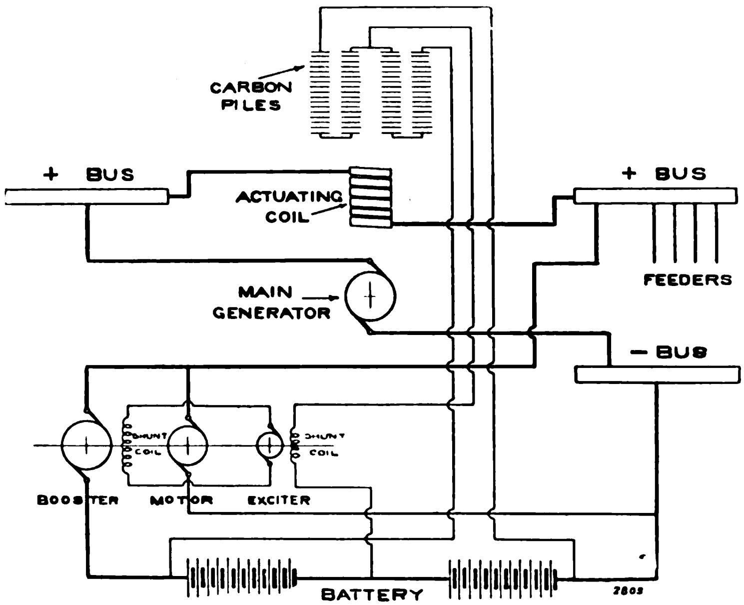


FIG. 2. "ENTZ" REGULATOR IN BATTERY BOOSTER CIRCUIT.

The load to be taken by the generators may be adjusted at any desired point by varying the tension of the above-mentioned spring, which adjustment is instantly made, and may be altered from time to time during the day to meet changes in the load conditions; the battery either simply "floating" or taking a continuous peak discharge, or a nett charge, according to the adjustment, while always taking automatically the momentary fluctuations of load.

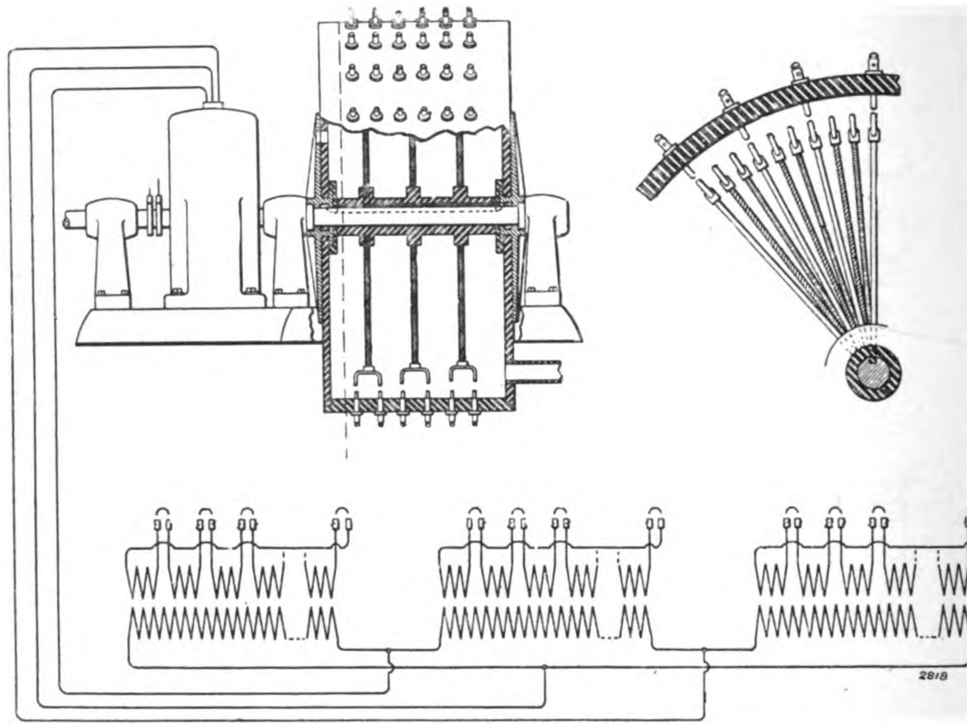
Arcing Plant for Fixation of Atmospheric Nitrogen.

To attain the maximum production of nitrous compounds from the atmosphere by the expenditure of a given amount of power, the effort has been to expose the air to arcs of maximum length and minimum volume. It was to secure this result that the Bradley-Lovejoy method, which was for a time exploited on a commercial scale at Niagara Falls, drew out the arcs between stationary and rotating platinum-pointed electrodes. Direct current at a potential of about 10,000-volts was used and an inductance inserted in the circuit arrested the formation of the arc while the gap was short and, by the power so absorbed, assisted the flame at its maximum dimension.

In the method of Bradley-Lovejoy a great number of these electrodes were mounted on a shaft and rotated in a cylindrical chamber with inwardly disposed stationary electrodes. As the movable arcing points swept by, the potential bridged the short gap and the flame hung on until the electrodes were separated a dozen or more inches. In this way several thousand arcs an hour were produced in the burning chamber.

It is upon a burning-chamber process similar in principle to the Bradley-Lovejoy construction, but employing alternating current, that a patent was recently granted to Dr. C. P. Steinmetz, who has succeeded in avoiding the use of separate arc circuits or the need of individual reaction coils in each branch of the main circuit. Since an arc of such small volume as is required for the efficient working of such a process represents only very little energy and cannot be continuously maintained in a reliable manner, it is necessary to employ a large number of arcs simultaneously, which, when established, are of short length and are then drawn out to their maximum length until they break, and this process is repeated in rapid and continuous succession. The air which is subjected to the action of the arcs is driven past the arcs in a continuous stream, thus removing the nitrous compounds which have been formed as rapidly as possible from the further action of the arcs, so that the dissociation of the compounds is prevented so far as possible.

Heretofore it has been deemed necessary to establish each of the numerous arcs either in an independent circuit or in a separate branch of a main circuit, and in either case, the expense of the apparatus was great and the complexity considerable.



THE STEINMETZ ARCING PLANT FOR FIXATION OF ATMOSPHERIC NITROGEN.

The potential of the arc circuit is necessarily high, since the longest possible arc is aimed at, and since, for mechanical reasons, the arc must be established without actual initial physical contact of the electrodes. For independent arc circuits, therefore, it was necessary to have either a high-potential generator with a great number of independent generating coils, or a low-potential generator with many independent generating coils, and in addition thereto as many independent step-up transformers. In either case, the apparatus was expensive and complex.

When the arcs were placed in parallel branches of a high potential main circuit, it was necessary to equip each branch with a reaction coil in order to prevent one arc from short-circuiting all the others; for one arc will always form before the others, and the resistance of the branch in which the arc is first formed will at once be lowered below the resistance of the other branches, and will thus short-circuit the latter. Reaction coils in the several branch circuits largely prevent this short-circuiting, but these reaction coils are nearly, if not quite, as expensive as independent transformers.

Dr. Steinmetz's invention involves the use of an ordinary three-phase generator of medium potential, direct-connected to the shaft carrying the rotating electrodes in the burning-chamber. A single three-phase step-up transformer has the independent secondary windings for each phase divided in open sections, which are closed upon each other by two arcs for each section, so that all the arcs fed by one phase are in series. A diagram of this arrangement is shown in the accompanying drawing. When these arcs are broken, the arcs fed by the next phase of current are established, and these are in turn replaced by the arcs fed by the third phase. In this way an ordinary three-phase generator and a single, three-phase, slightly modified transformer take the place of the complicated apparatus formerly used. The arc-establishing device, shown in the upper right-hand corner of the illustration, is, as here drawn, modified to provide for the condition that each phase of current shall feed a separate group or set of numerous arcs in series.

The length of the radial arms, the size of the staples and the length of the pins which constitute the terminals are so chosen that

actual contact between the staples and the terminals is not made, but that an arc passing from terminal to staple and from staple to terminal may close the series connection between the sections of each independent secondary coil. The air-gaps in the secondary circuits are, therefore, in the operation of the apparatus bridged by electric arcs.

The radial arms of each order are spaced 15deg. apart, but the arms of any order are shifted with reference to those of the preceding order by 5deg.

In the example here given there will, for each complete rotation of the shaft, be formed, lengthened, and broken, 3456 arcs.

Seeing at a Distance.

M. JULES ARMENGAUD, a well-known engineer of Paris, has recently experimented with image transmission to a distance, and hopes, by means of his apparatus, to solve this very difficult problem. This refers to what may be called "seeing at a distance," and not to the sending of photographic views over a wire, as, in fact, the latter is now accomplished in a very satisfactory manner by Dr. Korn's apparatus, which has already been described in THE ELECTRICAL MAGAZINE. What M. Armengaud wishes to carry out is a method of direct vision by the use of a selenium cell and a rapidly moving apparatus which will cover all the parts of an image in a very short space of time, and thus give a practically permanent impression of the whole image on the retina.

Writing in *The Western Electrician* Mr. A. de Courcy cites two generally recognised methods by which we may hope to solve the problem of "seeing at a distance." One of these is to decompose a photograph into a number of points, as we have in a half-tone plate, and to transmit each of the points in succession by means of a selenium-cell device. At the receiving station a permanent record would be made of each of the points in a suitable apparatus, so as to reproduce the image in the form of the original.

However, as the number of points is very great, even for a small image, such a method would require a considerable time to cover all the parts of the photograph, or a direct image projected by a camera, and for this reason inventors seek rather to solve the problem by the second method, which consists of covering all the points of the image by a rapidly moving device and to project the light from each on to a selenium-cell apparatus.

The receiving device would move synchronously with the former and would throw a moving spot of light upon a screen so as to reproduce all the parts of the image before the eye would have lost the impression. This would require the whole reproduction to be made within 0.1 second. In this case the disadvantage lies in the great speed which is needed, for a great number of impulses must be sent over the line within this time. The inertia of the selenium cell is another factor, and a leading one, which must be contended with in this solution. Nevertheless, the attention of inventors seems to be turned rather to this method, inasmuch as the other method is counted as almost impossible to carry out in practice.

M. Armengaud hopes to construct an apparatus which will first cover the whole of the image within 0.1 second and at the receiving end will reproduce it within the same time upon a screen. He has already devised an apparatus, which is illustrated herewith, in order to allow the light from all the points of the image to fall upon the selenium cell in rapid succession. In Fig. 1 is shown a diagram of the transmitter and receiver. The transmitter, seen on the left, consists of a selenium cell *S* upon which the image, a portrait for instance, is thrown by means of a lens placed at the left, so as to cover the surface of the cell.

But it is desired to have the cell lighted, not by the whole image, but by a certain small portion of it, representing a "point." This M. Armengaud carries out by adapting a moving-picture film apparatus for the purpose. Between the image and the selenium cell is mounted a vertical strip of opaque celluloid photographic film, which runs upon rollers at the top and bottom. This film *A* serves as a shutter, and it has in it a series of horizontal slots which allow the light to pass through. Between this film and the cell is a second strip *B*, which is mounted like the former upon rollers, but running horizontally. It likewise carries a set of slots for the passage of the light.

The effect of such a combination will be noticed in Fig. 2, where *B* is the horizontal

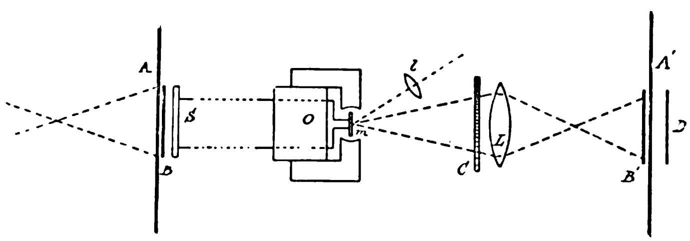


FIG. 1. THE TRANSMITTER AND RECEIVER.

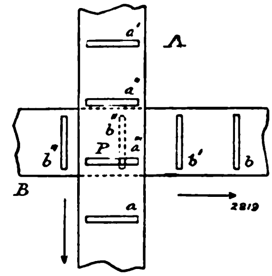


FIG. 2. THE MOVING FILM.

strip which moves in the direction of the arrow. It carries the equally spaced slots or openings *b*, *b'*, &c., which thus pass in succession across the image. In like manner the vertical band *A* travels from top to bottom, and carries the set of slots *a*, *a'*, &c. Where the vertical and horizontal slots cross, there will be formed a square opening *P*, which has the size of the element or "point" of the image, and only the light from this point will fall upon the selenium, as all the rest of the light is cut off by the dark strips.

The movement of the vertical band *A* is rapid, but not continuous, as the band is made to stop for a fraction of a second at the proper intervals. Taking the case where it is momentarily stopped, the slot *a'''* will have a certain position before the image. The horizontal band will at the same time be in movement so as to allow the transparent spot caused by the crossing of the bands to sweep horizontally across the whole image from left to right. When this is done, the vertical band will be again displaced and a new horizontal slot will come over the image. But it will occupy a position which is higher up (by the width of one point), so that when the next vertical slot of the other band now moves across, the transparent part will sweep across a fresh portion of the image, and so on, until the image is entirely covered from bottom to top. These movements are carried out by an appropriate mechanism by which the film bands are run as endless belts upon sets of rollers, driven at the desired rate by sets of gearing. A small electric motor runs the whole mechanism.

As will be seen, this is only the first step in the problem of electric vision. It remains to be seen how the selenium cell will behave under such circumstances. The inertia of the selenium can be overcome to some extent by the use of a number of different cells, say, 10, placed on a rotating support so that one cell is brought automatically opposite the image at each impulse of light; thus the inertia effect would be reduced to one-tenth of what a single cell would give, supposing that the cell would have time to recuperate before it came round again. This method was suggested some years ago.

It then remains to devise a suitable receiver which will respond to this rapid succession of impulses. The inventor wishes to use the type of receiver which is shown in Fig. 1. It consists of an oscillograph *O* which will respond to very rapid impulses and will throw a spot of light coming from *l* through a screen *C*. This screen is of graduated thickness, so as to let pass different amounts of light according to the position of the beam (M. Belin's method). The resulting light is sent by the lens *L* upon the screen *D*. Before the screen is placed a set of crossed vertical and horizontal moving bands *A* and *B'*, as in the transmitter. The result will be that the transparent part or spot will cover the whole image in one-tenth second, and, on the other hand, the light will be constantly varying by means of the oscillograph (which receives the current from the selenium cell), so that there will be found a reproduction of the original image upon the screen and the eye will perceive the entire image at once.

Ammeter for Very Large Currents.

CONSIDERABLE difficulty is experienced in making exact measurements of large alternating currents considerably exceeding 1000amp., such as are used in electric furnaces for electric welding, &c.

In practice these large currents are measured with the aid of a series transformer. The ratio of the transformer is computed and its small secondary current is measured by an alternating-current ammeter which has been accurately checked by any of the well-known methods. The primary current is then known as accurately as the calculated ratio of the series transformer.

A true and accurate value of the ratio of a series transformer cannot, however, be obtained by computation. The ratio should be obtained experimentally, under the conditions of frequency, wave form and load, in which the transformer is to be used to get an accurate determination of the heavy primary current from a precise measurement of the small secondary current.

There is, therefore, need of a standardization instrument, of not excessive cost, which can be inserted directly in an alternating-current circuit, carrying any current over 1000amp., and which will measure this current with the same precision as small alternating currents are measured. The first simple and inexpensive instrument which answers this purpose is the mercury ammeter designed by Dr. E. F. Northrup and described by him in the August issue of the *Journal* of the Franklin Institute. The instrument is based on the "pinch effect" which was described in THE ELECTRICAL MAGAZINE, June, 1907.

The action of the instrument depends upon the essential principle that when a current, direct or alternating, passes through a conductor, there is set up in the conductor an attraction towards its axis of all the imaginary elemental filaments of the conductor. This attraction, when the conductor is a liquid conductor suitably confined in an insulating tubular space, results in a difference of hydrostatic pressure between the axis and the circumference of the conductor. This difference in pressure in a conductor of circular cross-section is numerically equal to the square of the current strength and inversely equal to the cross-sectional area of the conductor.

If the conductor is made up of two or more liquid portions in circuit with solid portions the differences in pressure set up by the passage of the current in the liquid portions may be added, like electromotive forces, in series, and the resultant pressure difference utilized to raise a column of liquid. This raised liquid column may be used to directly measure the value of the current, or the motion of the raising column can be communicated to any style of pointer moving over a scale or dial.

The liquid found to be best adapted to use in the construction is mercury. The height to which the mercury column will rise with a given current may be magnified for convenience of observation, but not for accuracy, by causing the pressure to be transferred to a column of coloured water.

In practice it is found necessary to use two mercury pockets or cells and to make these but $\frac{1}{64}$th of an inch in their axial dimension. On account of their short length and the proximity of massive copper blocks to rapidly conduct away the heat, great current densities may be passed through the cells. In fact 20,000amp. to the square inch gave a rise in temperature in the cell as measured by a thermo-couple of only 16deg. C.

Mercury has sixty times the resistance of copper, and hence, if this latter metal were to replace the mercury, current densities of 1,200,000amp. per square inch under like conditions could be passed through the short conductor. It may also be shown that, keeping the axial length of the cells always the same, the number of watts required to raise a column of water a given height is independent of the number of mercury cells used and the current passing.

It is found that approximately 1.4 watts is required for every inch rise of water. Hence, as an ammeter properly constructed can be easily made to dissipate 35 watts, it can be made to give a scale, using water, 25in. high.

When, however, water is used, the instrument has a temperature error of $\frac{1}{8}$ per cent. per 10deg. C., as this represents the increase in the lightness of the water, which expands one part in four thousand for every degree Centigrade. For precision work the error may be calculated and allowed for, as the temperature is easily measured. If water is not used the rise in the mercury column may be directly observed with a

cathetometer or microscope, in which case the possible precision is very high.

The indications are absolutely the same with direct and alternating currents, and strictly follow the square law. It is proposed to construct carefully a large mercury ammeter with all its dimensions accurately measured and to employ it in the absolute determination of current.

The mercury ammeter may, if desired, have its constants obtained at one point on the scale by passing a large known storage - battery current through it; the remainder of the scale may then be laid off by calculation. By inserting this instrument in series with the primary of a series transformer of large capacity to measure the primary current, and by measuring at the same time the secondary current with the A.C.-D.C. comparator, or any instrument which has been checked by it, the ratio becomes accurately and experimentally determined. The series transformer with its constants determined in this manner becomes then a truly valuable adjunct in the measurement of large alternating currents. It only remains to determine the phase relations existing between the primary and secondary currents of the transformer to make of it a precision piece of apparatus.

The useful lower range of the mercury ammeter has not yet been fully determined, but though a 500amp. instrument is easy to construct, there would be little demand for instruments of smaller capacity, as below this, precise null methods are available.

The Leeds and Northrup Company, of Philadelphia, build these instruments to order if the minimum current required to be measured is not too small, say 500amp. The maximum current that can be measured may be anything.

Based in an ingenious way on a new principle, this ammeter represents certainly one of the most interesting developments in electrical instrument design and should prove very useful especially in electrochemical and metallurgical work, where very high-current circuits are general.

Electric Power in the Klondyke.

THE use of electrical machinery in the Yukon mining district of the Canadian North West has become general. Modern methods and modern machinery have supplanted the old primitive plants, and improvements are being made all over the district. According to the Canadian *Mining Journal*, scores of extensive large method mining plants have been installed in the Klondyke since the region began to emerge from the old conditions of individual operations. The investment in dredgers and hydraulic equipment has reached many millions of dollars, and this line of enterprise seems scarcely more than begun. In connection with the dredgers extensive outlay has been necessary for steam and water-power plants for generating electricity with which they are driven. For each hydraulic plant long ditch lines are often necessary, causing in many instances great outlay for pipe material for syphons, to say nothing of hydraulic giants and the other parts, apart from timber for flumes, penstocks and suchlike. The new style of electric elevators or lifts, handling tailings from ground, being worked hydraulically on the creek bottoms, also calls for considerable mechanical equipment. The framework of the lifts is entirely of steel; they carry a steel bucket line, similar to a dredger, and are equipped with two large centrifugal pumps to each lift, for handling water from the sump to the tailing boxes. The hydraulic giants used for washing the gravel down to the lifts are akin to the hydraulic plants used in the operation on hills.

The electrical equipment for conveying power is one of the largest items of expense. Transmission lines from a quarter of a mile to sixty miles long are installed, already conveying power. In connection with each line is the generating equipment in the form of dynamos driven by turbines or steam plants. Some of the dredgers are supplied with power from steam boilers aboard the craft, but the larger concerns have their steam or power plants ashore and electrical lines with which to convey the electricity to the dredgers. The several big companies branching out are planning the instalment of extensive power plants of the most modern character. The power will be generated from the vast natural water courses and conducted over hills and valleys by overhead high-tension lines. The many new hill groups organized for working hydraulic plants will demand much more new equipment before long.

Manufacturing Progress

Electric Compressors.

THE Reavell air compressor is claimed to have as particular merits a very even turning moment and a compactness of design which have during the last few years brought this machine to the front in connection with mining work.

This compressor has four cylinders arranged radially in a circular shaped casing. Each of the four cylinders is fitted with a trunk piston and the four connecting rods are all driven by a common crankpin. The casing contains an annular space through which the cylinders pass, and which is used as a water-jacket. Each cylinder forms as it were a separate single-acting compressor, and as they all deliver into a common delivery passage a practically continuous delivery of air is secured and the compressors can be run at a relatively high speed owing to the pressure being always in one direction.

One of the chief features of this air compressor is that it has no suction valve, air being admitted above each piston by means of a port in the latter which coincides with a similar port in the top of each connecting rod during the suction stroke. Near the end of this stroke the piston over-runs the ports and cuts through the cylinder wall, thus making a direct communication between the cylinder and the suction chamber. This special feature alone is said to result in a gain of at least 5 per cent. in the volumetric efficiency as compared with compressors having spring-loaded valves, the cylinder being filled with air at atmospheric pressure at each stroke instead of at a reduced pressure due to the resistance of the valve spring.

The arrangement of cylinders in this compressor makes it particularly suitable for electric driving. The torque on the shaft is

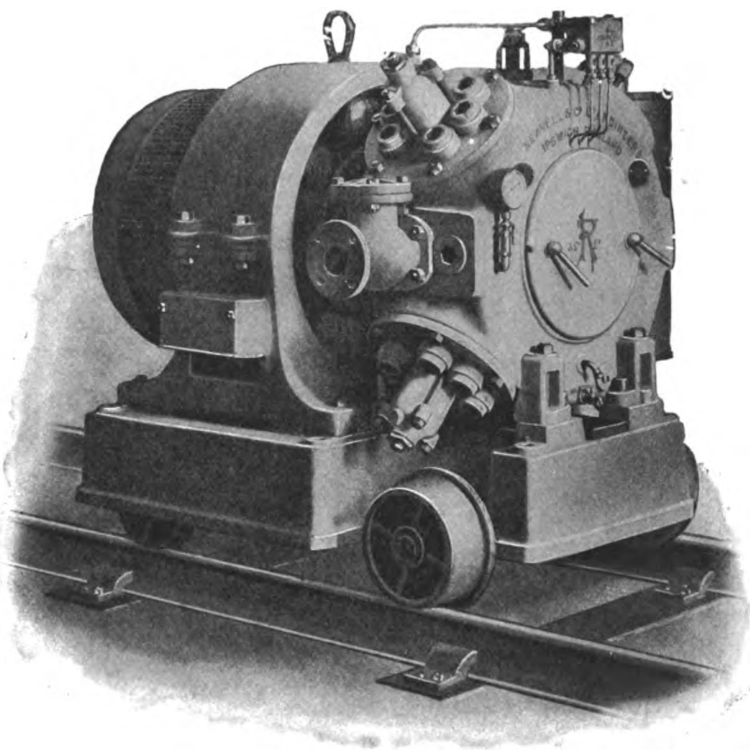


FIG. 1. REAVELL PORTABLE ELECTRIC COMPRESSOR.

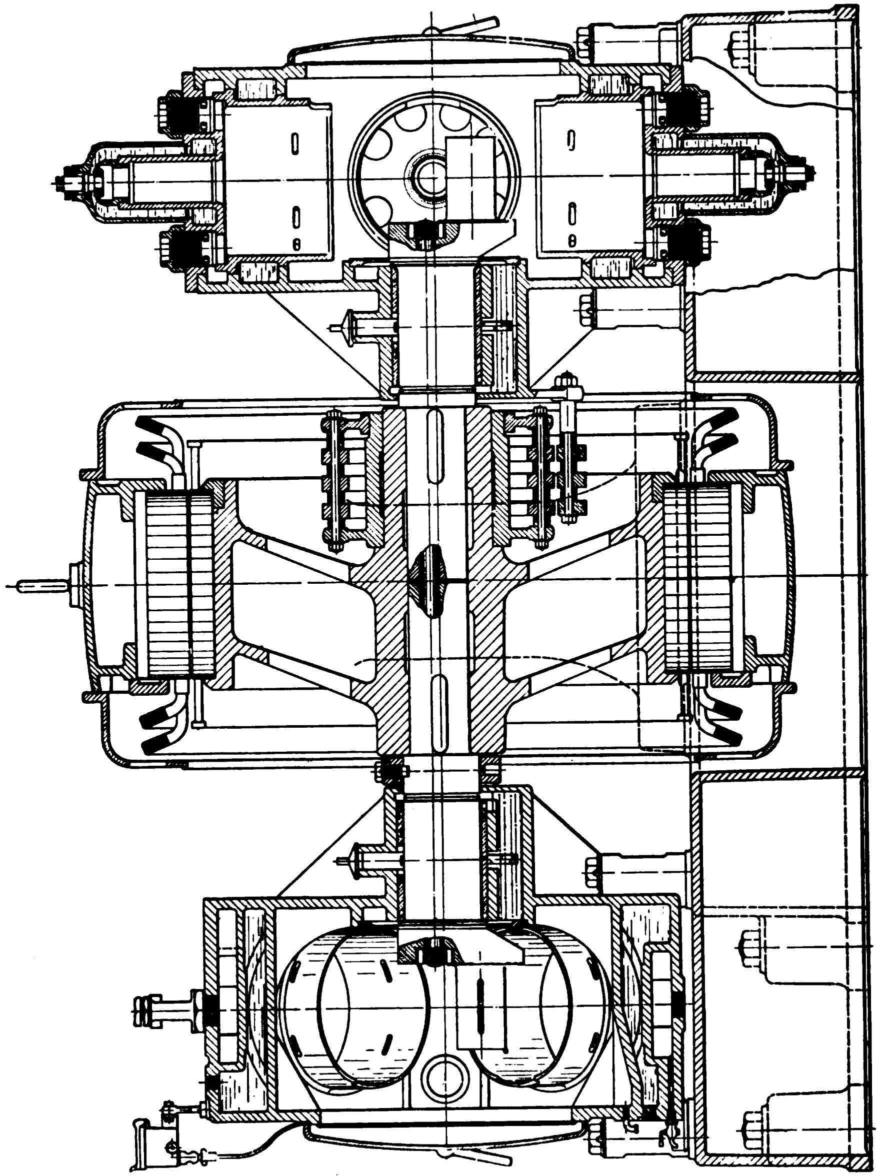


Fig. 2. Section of Reavell Double-ended Electric Compressor.

practically constant and this enables the motor to work efficiently and without sparking. The compressor can either be driven through a gearing by high-speed motor or can be direct-coupled to the motor; this latter arrangement enables gears to be dispensed with and ensures a very quiet-running, efficient and compact machine. The direct-coupling is effected by building the armature on a spider which is bored to receive the extended compressor crankshaft. The outer end of the crankshaft runs in the bearing supplied by the motor makers. This direct-coupled plant has only two bearings, one forming the main bearing of the compressor, and the other the outer bearing of the motor. Alignment therefore is an easy matter to secure. The illustration Fig. 1 shows one of these air compressors, direct-coupled to an electric motor, mounted on wheels. The

identical plant illustrated is at work in one of the large collieries in South Wales, namely, Messrs. Guest, Keen and Nettlefold's.

These electrically driven compressors can be arranged with an automatic stopping and starting switch which automatically stops the compressor when a predetermined pressure has been attained in the receiver, and starts it when the pressure falls to a predetermined point.

The compactness of this arrangement, which can be made either single or double ended as required, has caused the electric compressor sets to be largely in demand for in-bye use in coal mines, and the compressor can be easily taken down the mine and placed close to the coal face. Messrs. Reavell & Co., Ltd., have supplied machines of this type to many collieries in England and abroad, and they have on order at the present time several electrically driven machines for colliery use in England. Some of these machines are fitted with variable-speed motors, so that the speed of the motor can be reduced as the pressure rises, thus reducing the output. This is a favourite method of governing.

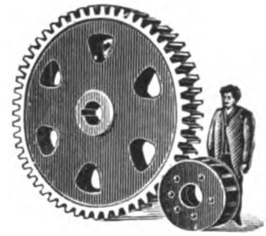
The illustration Fig. 2 shows the section of a double-ended compressor supplied to the Y.T. Grand Junction Gold Mining Syndicate.

A great feature claimed by the makers of these compressors is that all parts are made on the interchangeable system and spare parts can be ordered with a certainty that they will be a perfect fit.

The works of Messrs. Reavell & Co., Ltd., are at Ipswich, and they are always glad to see any friends interested in pneumatic work.

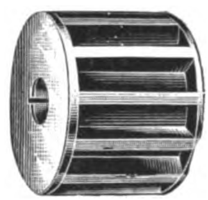
Buffoline Gears.

One of the most important of the many industries which have followed and are mainly dependent upon the universal usage of electric motors is the manufacture of flexible or non-metallic gearing. The use of leather or paper to form the body of high-speed pinions and bevel gears has become very largely standardised for certain services, and there is keen competition amongst the makers of this class of gearing. Remarkable progress has been made in the methods of manufacture; whereas the earlier examples were deemed good for general service under dry and clean conditions, they were often found to be susceptible to moisture to such an extent as to render them unsuitable for many services where their advantages of silent running, and the cushioning or shock-absorption between the driving and driven units, rendered their use most desirable. The fact that they are to-day more often adopted than metallic pinions for pumping and hauling plants in mines speaks for itself as to the high degree of perfection which they have attained.



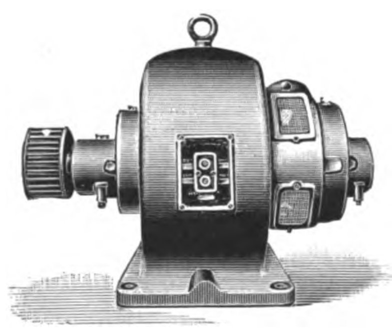
11ft. Machine-cut Gear.

The illustrations herewith show one or two forms of the patent Buffoline raw hide gears. These gears are manufactured from the best buffalo hides; they are very durable, and at high speed tests have proved to be of twice the strength of cast iron. When a Buffoline pinion is mounted on a motor shaft, and is put in mesh with a metal gear, a perfect drive is arrived at—there is no noise, no shock, and no vibration. Although the first cost of a Buffoline gear is more than that of a metal gear, experience proves that the difference is often very soon saved in the reduction of the bill for the upkeep of the plant.

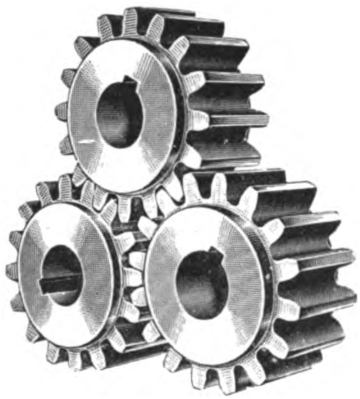


Buffoline Pinion.

For those engineers who prefer paper gears, the Buffoline Noiseless Gear Company make a special waterproof gear made of the strongest paper procurable, and built up on a special form of screwed bush.



Motor with Shrouded Buffoline Pinion.



STEEL PINIONS.

Whilst these paper gears give complete satisfaction, it is said that the raw hide gears are to be generally preferred, as under proper conditions they are more durable than those of paper. The only place for which the makers recommend the use of paper gears before raw hide is where it is very wet, as they can more easily be waterproofed.

Where a big reduction in speed is required the Buffoline Company recommend the use of their self-contained worm reduction gear box. This gear box consists of a phosphor-bronze worm wheel mounted in phosphor-bronze ring-oiling bearings, engaging with a case-hardened steel worm also mounted in phosphor-bronze ring-oiling bearings. The whole gear is neatly enclosed in an oil-tight case fitted with ball thrust bearings.

It is interesting to note that recent business done by this Company includes the supply of large quantities of noiseless and reduction gears of various forms and sizes to the mining districts of South Africa, which it is reported have given great satisfaction to the engineers engaged in the installation and maintenance of mining plants of all kinds in that country.

The Buffoline Noiseless Gear Company do not limit their work to the manufacture of the Buffoline and raw hide pinions, but also make fibre pinions, every kind of machine-cut all-metal gears in phosphor-bronze, gun-metal, cast iron, steel, &c. The illustrations show typical examples of the work turned out from their well-equipped shops at Levenshulme, Manchester, where large stocks of those gears in more frequent demand are held for immediate delivery.

Electric Heating and Cooking.

THE seventh edition of the General Electric Company's catalogue of electric heating and cooking appliances gives a good deal of specific information on the subject which will be read with exceptional interest. This firm has had the widest experience in the design and manufacture of electric heating apparatus, and the facts and figures quoted by them are of corresponding value.

Electric heating and cooking is a practical success, and has had the effect of splitting up cooking operations into what might be termed smaller units; they can now be done in a far more convenient manner, and at a moment's notice, without requiring a lot of preparation. It would seem that there is a general impression that electric cooking should be done by a combined stove in imitation of a gas cooker. Such an arrangement is not the best way of cooking by electricity. The very fact that electricity has made it possible to apply heat direct to the utensil itself (which cannot be accomplished by any other means) does away with the necessity of making a combined stove following the lines of the older devices. The proper method of cooking electrically is for each utensil required to be self-contained with its own heater, so that when that utensil has to be used, it is filled with the necessary food or water and connected to the source of heat by means of the plug or switch, and it can be placed anywhere to suit the individual using it.

To keep the utensils compact, a number of connection plugs can be provided on a wall, or at the back of a table, using the kitchen table top as a stand for the utensils, or a more convenient arrangement is as shown in the illustration. By using direct-heated utensils, cooking can be done with a consumption of less than half the amount of electricity that would be required by an "electric stove" composed of hotplates in imitation of a gas cooker.

The more important advantages of electric cooking methods are:

(1) Perfect cleanliness.
(2) Entire absence of smoke, smell or dirt from the utensils.
(3) The heat is confined to the utensil in use, and the cooking is, therefore, performed with greater comfort and cleanliness, and without the heated

and tired feeling always prevalent in other methods.

(4) Extreme convenience. The mere turning of a switch produces the necessary heat, so that it is always ready for immediate use. The utensils can be used on the table or other convenient place.

(5) A constant and even heat is maintained, thus preventing undue burning.

(6) Diminution of fire risk.

ELECTRIC COOKING OUTFIT.

The electrical supply companies are now universally supplying current at reduced rates for heating, and accordingly electric heating and cooking can be adopted with practical economy. It should be remembered that the consumption of current can be instantly stopped by turning the switch or withdrawing the plug, and it is only required while the actual utensil is in use. It is possible to cook a dinner for eight people with a total expenditure of $4\frac{3}{4}$d., with current at 1d. per unit. It is somewhat unfair to compare the cost of heating or cooking by electricity with other methods without first considering the immense advantages of the electrical method. By electricity all the objections experienced by any other method are removed in one sweep. The convenience of an electric kettle, domestic iron, small saucepan, or a coffee maker in everyday use in a household has to be experienced to be appreciated. The using of such articles becomes a pleasure, and does away with an immense amount of trouble. The cost of normally using all these smaller articles together for twelve months is about 15s., a very small item compared with the immense convenience.

In the design of the General Electric Company's cooking appliances several systems of wiring are used, each adapted to the article most suited for the purpose. The enamel "Archer" system has been improved during recent years and is the result of vigorous testing and experimenting. It is composed of a bottom layer of a semi-refractory coating fused into the iron at a very high temperature. On this coating are laid wires of a special composition, which are surrounded, in process, by a second coat of special enamel, which ensures the wires remaining in their proper position. This is again covered by a third coat of a special enamel, and the whole is fused into an integral mass sealing the conductor up inside. Many of the kettles have been in constant use every day for many years, laundry irons have had a life of 3800 hours at high temperature, and electric glue pots have been in constant use for eleven years without a sign of breakdown.

All the articles described are of high efficiency—that is to say, the electrical conductor or resistance is in close contact with the under surface of the article to be heated, being only separated therefrom by an average of .036in. thickness. The chief loss of heat, in any method of applying heat, occurs through imperfect conduction from the source to the substance to be heated. Still air is a very imperfect conductor of heat, and, therefore, any system which has an air space between the source and the substance is wasteful and inefficient. It is impossible to apply the resistance directly on to the metallic surfaces for obvious reasons, but in this process it is brought very close to same, separated only by sufficient heat-conducting medium to electrically insulate the resistance from the metal, and this medium, being fused practically as an integral part of the metal,

forms a splendid heat-conducting medium, giving an efficiency of 90 to 97 per cent.

Articles like ovens, saucepans, dish heaters, &c., are made with several circuits when necessary for the purpose of regulating the heat as required. Such articles are fitted either with several switches or with multiple terminal plugs.

Utensils such as stewpans or saucepans, &c., for different circuits are listed as "slow circuit pans," "quick circuit pans," and "two circuit pans"—one circuit for attaining boiling point, the other for keeping at boiling point without waste of current. One pint of water is brought to boiling point (212deg. F.) in the kettles at the rate of 3700 watts per minute, starting from 60deg. F. Therefore, to find the number of watts required to boil one pint of water, divide 3700 by the number of minutes desired for boiling; or, to find the time required divide 3700 by watts specified.

If time desired = 10 minutes, then

$$\frac{3700}{10} = 370 \text{ watts required to boil 1 pint.}$$

Or, if watts specified = 370, then

$$\frac{3700}{370} = 10 \text{ minutes to boil 1 pint.}$$

This formula refers to all covered vessels which boil water. A two-pint kettle taking 800 watts will boil in $9\frac{1}{4}$ minutes.

Nearly all the kettles, saucepans, and other goods for boiling or heating water are fitted with a patent fusible cut-out which prevents damage to the utensil if it be put on to circuit without water in, or allowed to boil dry. It is fitted as a standard and forms a thorough protection against one of the chief troubles in connection with electric heating apparatus.

The illustration shows an oven for roasting, baking, or stewing, with a hot chamber on top for heating plates, or keeping food warm; a large vegetable pan with steamer; a small pan for sauce, milk or small vegetables, &c.; a hotplate for boiling flat-bottomed utensils on, or keeping large pans gently simmering, &c.; and a frypan for chops, steaks, fish, &c. The outfit can be used anywhere, on a handy table or dresser—against a wall is the best, so that the mains carrying the current can be easily brought up to it. It is only necessary to connect the cable to the two terminals under the oven. The utensils are connected for use by pushing the plugs, on the flexible ends, into the sockets on the oven sides; the plug at the other end of the flexible goes on the utensil.

The approximate cost of cooking a dinner for about six to eight people with this outfit will be as follows.—

The oven for cooking the joint and pastry ... consumes about	$2\frac{1}{2}$ units.
The large saucepan, used with the steamer, for potatoes, vegetables or puddings, consumes about	$1\frac{1}{4}$ "
The smaller saucepan, for sauces, melted butter, &c., consumes about	$\frac{1}{4}$ "
The hotplate, probably on circuit for $1\frac{1}{2}$ hours, consumes about	$\frac{3}{4}$ "
The current consumption for a good plain dinner for eight persons, including soup, is therefore about	$4\frac{3}{4}$ "

which, at 1d. per unit, costs $4\frac{3}{4}$d.

Electrical Advertising Signs.

The logical solution of the problem which is at the moment concerning the minds of central station engineers, viz., a decreasing demand for current, due to the increasing use of high efficiency metal-filament lamps, is to provide fresh uses for electrical energy. Cooking and heating are the first means which suggest themselves, but the man in the street is only very slowly coming to take a practical interest in electric heating and it will be long before the older methods of cooking by gas and coal fires are superseded to any great extent.

There is, however, a path leading to an increased demand for current, which, although trodden before, has not yet been beaten to such an extent as to render any fresh developments in this direction a mere repetition of what has already been accomplished. It is not an exaggeration to say that what has been done is somewhat of a rudimentary nature Perhaps this is due to the fact that advertising by electric signs is of comparatively recent growth, and as yet the unlimited possibilities of this field for business have not been fully recognized. One point is certain: until recently no effort has been made to place this profit-bringing form of advertising within the reach of those firms whose expenditure on publicity runs

FIG. 1. LETTER OF THE SIMPLEX SIGN.

only to the modest £100 or so per annum. The current used by the usual form of sign would alone account for more than this amount.

As the proper season for pushing these goods has already arrived, no excuse is necessary for dealing with them at length. Reference has been made to the heavy current consumption of the illuminated letter outlined by lamps, and satisfactory as this may be from the central station engineer's standpoint, the latter is sufficiently far-sighted to recognize that this heavy current consumption prevents their universal adoption, and he will, in company with the advertiser, welcome any form of sign which, while losing nothing in advertising effect, costs less to keep running.

A new form of sign put on the market by Simplex Conduits, Limited, judging from the approval with which it has already been received on all sides, would appear to have solved this difficulty. These signs are of circular shape made in conical form of specially prepared tin to give a maximum effect from a reflective point of view. They are put on the market at a price which will appeal to small retailers, ranging from a matter of 30s. to £4 10s. each according to the size and the nature of the advertising devices incorporated. The particular point in connection with these signs is that they require but one lamp each to efficiently and effectively illuminate them, so that not only are they cheap in first cost, but the expense entailed in keeping them running is practically nil. The effectiveness of the signs is greatly enhanced by the attachment of a special flasher made by the Company, so that the light is continually going in and out. These flashes, working on a thermal principle, cannot possibly get out of order, and require no attention whatever.

An illustration is shown of one of these circular signs, showing the letter "S," a number of which can be used for building up any word in which by the use of special glass an effect is produced during the daytime equal to any other form of painted sign. In this case the economy in working would be most marked. Comparing the sign made up of Simplex signs requiring only one lamp each as against the usual form of gilt letter outlined by a number of lamps, the working cost comes out at less than one-fifth of the amount that would be expended in the latter case.

The Simplex Company have also put on the market a moving sign which provides an endless blending of colours in such a manner that the attention of the passer-by is immediately attracted. These also only require one lamp, and their construction is of such a simple nature that a change in colour effect is a question of only a few shillings expenditure; whilst they are rather higher in price than the fixed variety, they are yet not so expensive as to prohibit their use by the small shopkeeper.

The Company adapts the principle of working these signs to any form of sign that the advertiser may desire to have. It should be borne in mind, however, that effective results can only be obtained by using the special lamps supplied for these signs, and that no results can be obtained from an ordinary incandescent lamp with an egg-shaped bulb.

For some reason or other, business in electrical signs has hitherto only been dealt in by the actual sign-makers; electrical dealers and contractors have been precluded from doing business in these very profitable side lines. The Simplex Company has organised a selling system to endeavour to divert most of the business to the electrical contractor.

As a suggestion the illustration, Fig. 2, is an example of a sign which every contractor should display in his window. The cost of running is negligible, and now that the new lighting season has arrived, it will be found a cheap form of attracting customers, not only to electric signs, but to other goods displayed by the contractor in his window.

FIG. 2. SIMPLEX SIGN FOR THE ELECTRIC CONTRACTOR.

Those interested should write for particulars to the "Sign Department," 113-117, Charing Cross Road, or better still, call and inspect the varied range of applications displayed in the Company's show rooms at 11, Denmark Street.

Life-saving Appliances in Mines.

AFTER the recent terrible colliery accident too much prominence cannot well be given to all life-saving apparatus or indeed any appliance which by its employment might possibly avert such terrible catastrophes.

Safety Lamps.

It is essential with a safety lamp to have one that cannot be tampered with, or if tampered with does not become a source of danger. To prevent the opening of a safety lamp it has for years past been customary to make lamps so that they could not possibly be opened except with the aid of some special key or appliance in charge of the deputy. The objection to such methods is that miners have to travel backwards and forwards, frequently long distances, before arriving at the station where the deputy and unlocking apparatus are to be found. This not only causes a considerable loss of valuable time, but may easily be the direct cause of accidents, as it is most dangerous to travel in any mine without a light, especially on engine planes. To try to force the lock or otherwise tamper with it in order to get the lamp relighted might at times be a great temptation. Messrs. Ackroyd & Best have lately introduced a safety lamp which can be relighted by an electric spark without unlocking the lamp. Another most interesting and important improvement in this direction in that which the Wolf Safety Lamp Company have lately invented, whereby the lamp need never be taken to any station or specially deputed authority to be unlocked or relighted. The lamp can be relighted at once, without being opened in any way, by simply turning a little revolving spindle which projects through the bottom of the lamp case. This spindle has fitted to it a metal rubbing friction plate which, when revolved, rubs against a metallic bar, about one inch long and one eighth inch thick, of a special composition or alloy consisting of iron and the three rare metals thorium, cerium, and lanthanum. The rubbing friction of the revolving disc and the bar produces live sparks which easily ignite the naphtha gases escaping from the wick fixed alongside. In this manner the lamp can, it is asserted, be re-lighted 9000 times before replacing the bar of special alloy, so that it can be used for two years.

Benzine, colza, or acetylene are used in these lamps, which are of exceptional brilliance in their illuminating power, and no smoke is produced in operating the ignitor. A large acetylene safety lamp of 60c.p. for shaft bottoms, which gives a powerful light, and another for officials, of fully 14c.p., are also made by this firm. Such acetylene lamps are very sensitive to firedamp, indicating as little as 1 per cent. of firedamp.

Rescue Apparatus.

Next to the safety lamp comes the apparatus for saving life after an accident has taken place. Of these there are many. The "Fleuss-Siebe Gorman" and the "Draeger" apparatus are two of the best known. The former claims to be the simplest and lightest (total weight fully charged being 30lb.) and the most compact and comfortable. It is claimed that a man can put the apparatus on his back without assistance and be ready for work within one minute from the time when the order to get ready is given. The cost of recharging the apparatus is 4s.

The Draeger rescue apparatus belongs to the type employing compressed oxygen.

The expired air is drawn through two purifiers (containing, on twenty trays, porous grains of caustic potash and soda) by means of an injection which is worked by the force of the compressed oxygen. The purified air is conducted through a surface cooler, and then receives a fresh supply of oxygen equal to two litres per minute. The apparatus can be worn either with a helmet or a mouthpiece with nose clip and smoke goggles. The latest helmet type is supplied with an electric safety lamp which permits the wearer to use both hands. The lamp is fed by an accumulator which is placed on the back of the head, and forms at the same time a protection for the head. In addition to the lamp the helmet is further fitted with a telephone which enables the wearer to keep up continuous communication with the outside. By means of a pneumatic tube inside the helmet, which can be pumped up by the wearer when the helmet is put on, an absolutely air-tight mask is fitted round the face. The Draeger has been most successfully tested, and found efficient, at such great colliery accidents as those which took place at Courieres collieries in France, and lately at the Hamstead colliery, and many others, in England, France, and Germany, and has already been the means of saving thirty-five lives.

Another interesting Draeger apparatus is that employed for reviving miners who have been overcome or rendered unconscious by the dynamite smoke or other fumes. The injurious gas is automatically drawn out of the lungs, and it is replaced by fresh air enriched by oxygen. It is very simple and easily handled, and can be strongly recommended for employment in metalliferous mines where the "gassing" of men after imperfect dynamite explosions is unhappily not at all an uncommon occurrence, especially where black or coloured coolie, unskilled labour has to be employed, as in the gold mines of the Witwatersrand or West Africa and India.

Manufacturers

are invited to supply particulars of new specialities, important contracts, &c., for publication in the "Manufacturing Progress" section of *The Electrical Magazine.*

Manchester Exhibition.

THE following is a complete list of the firms who have, up to the time of going to press, booked space at the forthcoming Electrical Exhibition :—

Abbey Electric Co., 17, Victoria Street, S.W.
Areo Automatic Fire Alarm Co., 66, Cheapside, E.C.
Allen Clement, 36, Wilmslow Road, Rusholme, Manchester.
Adams Manufacturing Co., Ltd., 106, New Bond Street, W.
Aerators, Ltd., Prana Sparklet Works, Upper Edmonton, N.
Aron Electricity Co., Ltd., 80A, Salisbury Road, Kilburn, N.W.
Arcalia Electrical Manufacturing Co., 504, Stockport Road, Longsight.
Ashton, H., 8-10, Bull's Head Yard, Manchester.
Automatic Machine Co., Collier Street Works, Salford.
Bateman Machine Tool Co., Balm Road, Hunslet, Leeds.
Birch, G., & Co, Ltd., engineers, Manchester.
Bell Rock Belting Co., 24, Gravel Lane, Salford.
Bate, C. D., & Co., 40, Brazennose Street, Manchester.
Brayshaw, Ltd., engineers, Manchester.
Birch, J., & Sons, 3, London Wall Buildings, London.
British Thomson-Houston Co., Ltd., Rugby.
Blackman Ventilating Co., London.
Bullers, Ltd., 6, Lawrence Pountney Hill, E.C.
Blackwell, R. W., & Co., Ltd., 14, Great Smith Street, S.W.
Batty, W., & Sons, Ltd., 7-9, Market Street, Manchester.
Babcock & Wilcox, Ltd., 14, Deansgate, Manchester.
Browett, Lindley & Co., Ltd., Patricroft, Manchester.
Bailey, W. H., & Co., Ltd., Salford.
Berry, Skinner & Co., 78, Upper Thames Street, E.C.
Beanland, Perkins & Co., Leeds.
Bertram Thomas, Hulme, Manchester.
Bray, Markham & Reiss, Ltd., Spring Gardens, Manchester.
British Westinghouse Co., Trafford Park, Manchester.
Brown, F. V., & Co., 3, Cross Street, Manchester.
Brown, Boveri & Co., Ltd., Caxton House, Westminster, S.W.
Bruce, Peebles & Co., Ltd., Basildon House, Moorgate Street, E.C.
Bullough's Adjustable Rail Joint Support Co., Ltd., Liverpool.
Brady, G., & Co., 49, Pott Street, Ancoats, Manchester.
Bates, W. J., & Co., Denton, Manchester.

Boddy, G. M., & Co., Newington Works, Liverpool.
British Insulated & Helsby Cables, Ltd., Prescot.
Broadbent, T. W., Ltd., Huddersfield.
Carbone, Le, 17, Water Lane, Great Tower Street, E.C.
Chamberlain & Hookham, Ltd., Birmingham.
Churchill, Chas., & Co., Ltd., 6, Oxford Street, Manchester.
Clipper Belt Hook Co., 251, Deansgate, Manchester.
Collier, J., & Co., Manchester.
Combination Metallic Packing Co., Hillgate, Gateshead-on-Tyne.
Concordia Electric Wire Co., Ltd., 64, Salisbury Road, Kilburn, N.W.
Consolidated Pneumatic Tool Co., Ltd., Bridge Street, S.W.
Crypto Electrical Co., 155-157, Bermondsey Street, S.E.
Cunliffe & Croom, Ltd., Manchester.
Cutler, Wardle and Co., Ltd., 35-37, Dickinson Street, St. Peter's Square, Manchester.
Crossley Bros., Ltd., Openshaw, Manchester.
Chorlton & Knowles, Boardman Street, Manchester.
Calmon Asbestos and Rubber Works, Ltd., (and Check Fire Door Co.,) 1-3, Trinity Place, Tower Hill, E.C.
Climax Fire Extinguisher Co., 11, Exchange Buildings, Manchester.
Congdon & Muir, 42, Deansgate, Manchester.
Dowsing Radiant Heat Co., Ltd., 24, Budge Row, London.
Drake & Gorham, Ltd., 66, Victoria Street, S.W.
D. P. Battery Co., Ltd., Bakewell, Derby.
Dugdill, John, & Co., Failsworth.
Daniel, T. H. & J., Ltd., 22, Henrietta Street, E.C.
Dey Time Registers, 100B, Queen Victoria Street, E.C.
Diesel Engine Co., Ltd., 179, Queen Victoria Street, E.C.
Dryden & Co., Preston.
Dunlop, D. N., Westinghouse Co's. Publishing Department, Trafford Park, Manchester.
Electrical Engineer, 139-140, Salisbury Court, Fleet Street, E.C.
Ebenestos Manufacturing Co., 127, Pomeroy Street, S.E.
Eckstein, Heap & Co., Salford.
Edison & Swan, Ltd., 36-37, Queen Street, E.C.
Electric & Ordnance Accessories Co., Ltd., Birmingham.
Electrical Engineering, 203-206, Temple Chambers, E.C.
Electric Journal, 17, Bouverie Street, E.C.
Electrical Field, 30-31, St. Swithin's Lane, E.C.
ELECTRICAL MAGAZINE, Bazaar Buildings, Drury Lane, W.C.
Electrical Power & Storage Co., Ltd., 4, Great Winchester Street, E.C.
Electrical Press, Ltd., 37-38, Strand, W.C.
Electrical Review, 4, Ludgate Hill, E.C.
Elkington, Ltd., 22, Regent Street, London.
Electrelle, Ltd., Spring Gardens, Manchester.
Electric Rifle Co., Shaftesbury Avenue, London.
Electromotors, Ltd., Openshaw, Manchester.
Elliott Brothers, Century Works, Lewisham, S.E.
Engineer, Ltd., 33, Norfolk Street, Strand, W.C.
Electrician Printing and Publishing Co., Ltd., 1-3, Salisbury Court, E.C.
Ernst, F., and Co., 31, New Bailey Street, Manchester.
Evans, E. M., and Son, 18A-18B, Fountain Street, Manchester.
Evershed and Vignoles, Ltd., Chiswick, W.
Emmott and Co., Ltd., 63, King Street, Manchester.
Electrical Times, 8, Bream's Buildings, Chancery Lane, E.C.
Faulkner, John, 13, Strangeways, Manchester.
Ferranti, Ltd., Hollinwood, Lancs.
Falk, Stadelman and Co., Ltd., 83-87, Farringdon Road, E.C.
Fittings, Ltd., 112, Victoria Street, London.
General Electric Co., Ltd., 67-71, Queen Victoria Street, E.C.
Glyco Metal Co., Ltd., 8-9, South Parade, Manchester.
Green, E., and Son, Ltd., 2, Exchange Street, Manchester.
Grevener, J. and H., Eldon Street House, E.C.
Goodalls, Weaste, Manchester.
Gilbert Arc Lamp Co., Ltd., Chingford, Essex.
Galloways, Ltd., Manchester.
Griffin, J. J., & Son, Kingsway, London.
Hall, J. P., and Co., Werneth, Oldham.
Harland, G. Bowden, and Co., 196, Deansgate, Manchester.
Hart Accumulator Co., Ltd., Stratford, E.
Herbert, Alf., Ltd., Coventry.
Hodgkinson, Jas. (Salford), Ltd., Pendleton.
Hoffman Manufacturing Co., Ltd., Chelmsford.
Hopkinson, J., and Co., Ltd., Huddersfield.
Howard Asphalt Troughing Co., Ltd., Trafford Park, Manchester.
Howden, J., and Co., Glasgow.
Howell, W. R., and Co., 42, Theobald's Road, W.C.
Hans Renold, Ltd., Brook Street, Manchester.
Heatley Gresham Engineering Co., Ltd., 110, Cannon Street, E.C.
Hacking and Co., Lord Street, Bury.
Hebblewaite Brothers, Ltd., Huddersfield.
Halcrow, J. (Nuremberg Engine Co., 18, Coleman Street, E.C.
Heyde, J. Bennet Von der, 6, Brown Street, Manchester.
Harper Electric Piano Co., Holloway Road, London.
Hughes & Stirling, Ltd., Liverpool.
International Electric Co., 55, Redcross Street, E.C.
International Time Recording Co., 151-155, City Road, E.C.
Kendal, J. Lomax and Co., Ltd., 4, John Dalton Street, Manchester.

Kennedy Bending Machine Co., 34, Norfolk Street, Strand, W.C.
Key Engineering Co., 38, Deansgate, Manchester.
Kirkpatrick and Rastall, 16, Barrack Street, Hulme, Manchester.
Kenyon, Alex., and Co., Victoria Bridge, Manchester.
Kerr, J., and Co., 62, King Street, Manchester
Kent, Geo., Ltd., 199, High Holborn, W.C.
Liverpool Electric Cable Co., Ltd., Liverpool.
Lancashire Electric Power Co., 196, Deansgate, Manchester.
Lancashire Dynamo and Motor Co., Ltd., Trafford Park, Manchester.
J. E. Lea, 28, Deansgate, Manchester.
Lyle Trading and Manufacturing Co., Ltd., Fleet Street, E.C.
Luke & Spencer, Ltd., Broadheath, Manchester.
Ludw. Loewe & Co., Ltd., 30, Farringdon Road, E.C.
Luke, H., Ltd., Brazennose Street, Manchester.
Manchester Corporation, Electrical Department.
Marshall, Percival & Co., 26-29, Poppin's Court. E.C.
Massey, B. & S., Openshaw, Manchester.
Matthews & Yates, Ltd., Swinton, Manchester.
Mayer & Schmidt, Offenbach-on-Main, Germany.
Mitcham Electric Fan Co., Ltd., 6, Broad Street Place, E.C.
Mirrlees, Watson & Co., Ltd., Hazel Grove, near Stockport.
Morgan Crucible Co., Ltd., Battersea Works, S.W.
Musgrave, J., & Sons, Ltd., Bolton.
McDermott, R. W., Ashton-under-Lyne.
Morton & Co., Liverpool.
Mirrlees, Bickerton & Day, Ltd., Glasgow.
Marples, Leach & Co., London.
Mawdsley's Ltd., 25, Victoria Street, London.
Mealy, T. H., 87, Stovel Avenue, Manchester.
McPhail & Simpson, Ltd., engineers, Wakefield.
Nalder Brothers & Thompson, Ltd., 34, Queen Street, E.C.
National Gas Engine Co., Ltd., Ashton-under-Lyne.
National Telephone Co., Ltd., Manchester.
New Gutta Percha Co., Ltd., Dashwood House, E.C.
Nuremberg Engine Co., 18, Coleman Street, E.C.
Noyes, C. J., Pendleton, Manchester.
O'Brien & Co., 5, Brazennose Street, Manchester.
Oliver Arc Lamp, Ltd., Woolwich, S.E.
Oliver Machinery Co., Ltd., 201-203, Deansgate, Manchester.
Premier Electric Lamp Co., Huyton Quarry, near Liverpool.
Price, Chas., & Son, Broadheath, Manchester.
Parmiter, Hope & Sugden, Hulme, Manchester.
Parsons, C. A., & Co., Leeds.
Pearn, F., & Co., Ltd., Manchester.
Pearson & Co., 51, Mosley Street, Manchester.
Phillips Commutator Grinder Co., Ltd., 95, Cannon Street, E.C.
Pinchin, Johnson & Co., Ltd., 26, Bevis Marks, E.C.
Pollock & McNab, Ltd., Bredbury, near Manchester.
Power Plant Co., Ltd., Temple Bar House, E.C.
Price's Patent Candle Co., Ltd., Battersea, S.W.
Premier Accumulator Co., Northampton.
Proctor, Jas., Ltd., Burnley.
Post Office, Manchester.
Phillips, J. W., 23, College Hill, London.
Phillipson & Co., Holland Street, Astley Bridge, Bolton.
Rapid Magnetting Machine Co., Birmingham.
Rhodes, J., & Sons, Ltd., Wakefield.
Richards, G., & Co., Ltd., Broadheath, near Manchester.
Ripolin, Ltd., 35, Minories, E.C.
Robinson, Thos., & Son, Ltd., Rochdale.
Robertson Electric Lamps, Ltd., Hammersmith, W.
Ross, A., Hotchkiss & Co., Ltd., 1, Glengall House, S.E.
Reyrolle, A., & Co., Ltd., Hebburn-on-Tyne.
Ronald Manufacturing Co., Barnsbury Street, N.
Sub-Station:
General Electric Co., Ltd., Manchester.
Ferranti, Ltd., Hollinwood, Lancs.
Bruce, Peebles & Co., Ltd., Basildon House, E.C.
British Westinghouse Co., Ltd., Manchester.
Schaffer & Budenberg, Ltd., Manchester.
Shaw, J., & Son, Ltd., Huddersfield.
Siemens Bros. Dynamo Works, Ltd., 196, Deansgate, Manchester.
Sisson, W., & Co., Gloucester.
Small Power Dynamo and Motor Co., Openshaw, Manchester.
Smith, Frederick, & Co.'s Wire Manufactures, Ltd., Salford.
Standard Machine Works, Ltd., Nottingham.
Steinthall & Boydell, Ltd., Manchester.
Stubbs, J., & Co., Ancoats, Manchester.
Sunbeam Lamp Co., Ltd., Gateshead-on-Tyne.
Supplies, Ltd., Liverpool.
Sanders, Rehders & Co., 108, Fenchurch Street, E.C.
Synchronome Co., 32-34, Clerkenwell Road, E.C.
Small & Parkes, Ltd., Manchester.
Traun, Dr. Heinr., & Sons, 8, Redcross Street, E.C.
Taylor, Garnett & Evans, Co., Ltd., Manchester.
Taylor, Tunnicliffe & Co., Ltd., Eastwood, Hanley.
Triumph Stoker, Ltd., Leeds.
Thornton, A. G., & Co., Ltd., Paragon Works, Manchester.
Union Electric Co., Ltd., Southwark, S.E.
Union Standard Machine Co., 165, Queen Victoria Street, E.C.
United States Metallic Packing Co., Bradford.

Vincit, Ltd., Victoria Street, London.
Vulcan Boiler Insurance Co., Ltd., King Street, Manchester.
Wellman-Seaver & Head, Ltd., Victoria Street, London.
Wright, A., & Co.. Ltd., Westminster Palace Gardens, London.
Whipp & Bourne, Switchgear Works, Castleton, near Manchester.
Wilson, L. E., & Co., 20, Cross Street, Manchester.
Walsall Hardware Manufacturing Co., Walsall.
Wallwork, H., & Co., Ltd., Roger Street, Manchester.
Worthington Pump Co., Ltd., 153, Queen Victoria Street, E.C.

Radio-Telegraphy.—By C. C. F. Monckton, M.I.E.E. (London: Archibald Constable & Co., Ltd., 10, Orange Street, Leicester Square, W.C. Price 6s. net.)

This is a book which, treating of its subject from the beginning and presuming little or no electro-technical knowledge of the reader, is bound to be widely taken up and will doubtless serve as a standard text-book to a large majority of the many men who are nowadays entering the wireless telegraph services. It forms one of the altogether admirable "Westminster Series" which Messrs. Constable are issuing and which deal with the science and practice of a wide range of industries.

In the course of a somewhat lengthy preface the author reviews the ground covered in his work and indicates the present conditions prevailing in the practice of radio-telegraphy as dependent upon international agreements. He also discusses the scope of the wireless telegraph and telephone and the respective merits of the several systems for various conditions of service.

The book opens with a chapter devoted to the general properties of electricity, and here the author is to be commended for the particularly lucid manner in which, with simple word and diagram, he sets forth the primary principles of the electric and magnetic circuits. In a like manner he deals with the subject of vibrations, and thus follows naturally into the history of wave-telegraphy and descriptions of the several systems evolved. Subsequent chapters deal with the more important methods in detail, the construction and arrangement of the apparatus used therein, and the practical work of the telegrapher. Typical examples of the Lodge-Muirhead, Telefunken, Poulsen, and Marconi telegraph stations are described.

The last chapter deals with the progress made in wireless telephony. There are three appendices: The Morse Alphabet; Definitions of Electrical Units; and an Account of the International Control of Radio-telegraphy. The work is thorough and concise, well-written and well-produced, and can be recommended as of particular value to those engaged in telegraphic practice and students who have that aim in view.

Popular Fallacies.—By A. S. E. Ackermann, B.Sc. (Eng.), A.C.G.I., A.M.I.C.E., M.S.I., Secretary I.M.E., Consulting Engineer. With Eight Full-page Plates (London: Cassell & Co. Price 6s.).

To start reading this unique little volume is to at once forget whatever may be more consequential or pressing. We are all more or less inquisitive, and reading this book even the most logical and matter-of-fact man of science will find that he has cherished some "fallacies." There are a thousand and one homely and general beliefs here exposed to ridicule and usually pulled to pieces shred by shred. It might be thought that such wholesale analysis could only mean a tiring repetition, but the author has triumphed in producing a book of a distinctive character which, once dipped into, compels the reader's attention to the end. Sometimes he is very serious and at great pains in setting out how he, by experiment, disproved the accepted truth—it is genuinely entertaining to picture this ardent stickler for the undiluted fact boiling eggs, par-boiling them, re-boiling them, cracking some, and so on, just to prove that the cook is wrong in her notions; then he gravely discusses the temperature differences and laws regulating fire-draught, to demonstrate the absurdity of the maid who leans the poker against the bars to coax the unwilling blaze; again he is deeply concerned in superstitions, holding up to ridicule a vast array of "truths" handed down to us from times ancestral. It is indeed the serious manner in which the author has performed his task that makes the book so very amusing. Of course such a work will undoubtedly be found informative, and perhaps it was even written with that object. Let it, however, be recommended as a "humorous and entertaining" work; no one will be disappointed who begs, borrows, steals, or has presented to him a book which is something different from every other and which can be read when business is done. It provides a wealth of material for discussion, despite the fact that the author would dispose of our pet notions so summarily, for, after all, the old beliefs, fallacies though they be, are not to be ousted from the family circle without a great struggle—and we

fear not then. In some cases one even hopes that the author may be unsuccessful, for many of the old-world "fallacies" are indeed "popular."

BOOKS RECEIVED.

Cranes, THEIR CONSTRUCTION, MECHANICAL EQUIPMENT AND WORKING. BY ANTON BÖTTCHER. TRANSLATED AND SUPPLEMENTED WITH ENGLISH, AMERICAN AND CONTINENTAL PRACTICE BY A. TOLHAUSEN, C.E. (LONDON: ARCHIBALD CONSTABLE & CO., LTD., 10, ORANGE STREET, LEICESTER SQUARE, W.C. PRICE 42S. NET.)

Handbook of Electrical Testing. BY H. R. KEMPE, M.I.E.E., M.I.C.E. SEVENTH EDITION, REVISED AND ENLARGED. (LONDON: E. & F. N. SPON, LTD., 57, HAYMARKET, S.W. PRICE 18S. NET.)

Electro-Metallurgy. BY JOHN B. C. KERSHAW. WITH 61 ILLUSTRATIONS. (LONDON: ARCHIBALD CONSTABLE & CO., LTD., 10, ORANGE STREET, LEICESTER SQUARE, W.C. PRICE 6S. NET.)

Industrial Electrical Measuring Instruments. BY KENELM EDGCUMBE, A.M.I.C.E., M.I.E.E. 240 PAGES, WITH 126 ILLUSTRATIONS. (LONDON: ARCHIBALD CONSTABLE & CO., LTD., 10, ORANGE STREET, LEICESTER SQUARE, W.C. PRICE 8S. NET.)

Transactions of the American Institution of Electrical Engineers. JANUARY TO MAY, 1907. VOL. XXVI., PART I. (NEW YORK: AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, 33, WEST 39TH STREET. 1908.)

New Catalogues.

Tubolite.—THE LINOLITE COMPANY, LONDON, S.W., send their latest price list of "Tubolite" fittings. A new pattern, No. 19, has been put on the market to take the place of standard pattern 20. The new pattern is fitted with porcelain lamp-holders, which are an advantage electrically and enable the fitting to be sold at 7s. 9d. per foot, wired and complete with English made lamps, a reduction of 1s. 3d. per foot on the price of pattern 20. Another new pattern, No. 39, will be found specially useful for very large shop windows, stage lighting, and other places where a powerful light is required, owing to the fact that it carries 32c.p. lamps.

Electric Power Plant.—MAVOR & COULSON, LTD., GLASGOW, send an interesting and well got up booklet the earlier pages of which illustrate standard types of electric generators and motors as manufactured by this firm, while following these are illustrations showing the application of electric motors to industrial purposes.

"Camel Hair" Belting, &c.—F. REDDAWAY & CO., LTD., MANCHESTER, send us their new and artistic catalogue. This is a very complete publication containing 100 pages and divided into five sections, with pages in French, Spanish, Chinese, and Japanese. Section I. includes a full report of exhaustive tests of "Camel" Brand belting by Mr. Hopkinson, M.I.C.E., of Manchester, proving the marked superiority of "Camel" belting over leather as a band for transmitting power. Section II. is devoted to canvas hose and fire appliances generally; section III. deals with patent pads or dry felts for calico printers, laundries, &c.; section IV. concerns mineralised rubber goods for general mechanical work, collieries &c.; section V. giving particulars of the "Sphincter Grip" armoured hose, with rock drill and pneumatic hose, and Reddaway's patent improved high-pressure hydraulic couplings.

Contact Voltmeters, Signal Lamps, &c.—UNION ELECTRIC COMPANY, LTD., LONDON, S.E. List No. 8012 gives particulars and prices of "Union" contact voltmeters, relays, signal bells and lamps.

Watertight Measuring Instruments.—UNION ELECTRIC COMPANY, LTD. List No. 8014 gives details and prices of "Union" watertight instruments, constructed and tested to work under actual pressure conditions. The cases are of various shapes, constructed of various materials and finished in different ways to comply with the requirements of practical working, and are fitted with instruments either of the electromagnetic type, moving-coil type, or hot wire type. The range of these instruments, both in amperes and volts, covers all the usual requirements.

Fittings for Telegraph and Telephone Lines.—INDIA RUBBER, GUTTA PERCHA AND TELEGRAPH WORKS COMPANY, LTD., LONDON, E.C. List No. 36 is a well-illustrated publication giving particulars and prices of insulators, fittings, and tools for telegraph and telephone lines.

Heating and Cooking.—GENERAL ELECTRIC COMPANY, LTD., LONDON, E.C.—Catalogue Section H illustrates and gives particulars of a wide range of electric heating and cooking apparatus. A specially interesting feature is the large range of "elevectors," the "Archer" system of heating by convection, whilst of equal interest is an electric cooking outfit, complete with plugs, switches, &c., for £18 10s., a remarkable illustration of the economy and comfort possible in the kitchen. Illustrations are given of electric kettles ranging in price from 10s. each, plain patterns, to £10 10s., silver-plated on nickel silver. Needless to say, such articles as urns, coffee machines, hot-water jugs, food warmers, toasters, tailoring and laundry irons, soldering irons, glue pots, &c., are exhaustively dealt with.

Wires and Cables.—SIMPLEX CONDUITS, LTD., BIRMINGHAM. Catalogue Section W gives details and prices of Simplex wires, cables, flexible cords, telephone cables, and bell wires, also prices of Simplex jointing material, Leclanché and dry cells.

Electric Cooking.—SIMPLEX CONDUITS, LTD. Catalogue Section C is an artistic publication giving illustrations and prices of Simplex electric kettles, water and milk heaters, hot - water jugs, coffee machines, plate and food warmers, egg boilers, sterilizers, &c. Electric curling - tongs heaters, electric irons, sealing-wax heaters, &c., are also included in the list.

Iron-Clad Switches, &c.—PARMITER, HOPE & SUGDEN, MANCHESTER, send a well got-up catalogue illustrating and giving prices of Ajax switches, iron-clad fuses, power boards, fuse boards, distribution boards, motor starters, &c.

"D.B." Projectors.—W. J. JENKINS & CO., LTD., RETFORD, send us an illustrated booklet describing the "D.B." Projector, a simple and efficient machine for charging gas retorts and coke ovens, the operation of charging being also described. These machines are in use in the British Isles, Australia, New Zealand, South America, &c., &c.

"Safe" Guards for Electric Lamps.—B. T. DAVIES & CO., BIRMINGHAM, send pamphlet illustrating their electric lamp guard. These guards prevent the removal of lamps by unauthorised persons; there are no springs or loose parts for fixing, and there is no brass gallery to obstruct light. They are easily fixed to any standard lamp holder.

Folder for Central Station Engineers.—UNION ELECTRIC COMPANY, LTD. This company has recently issued a folder drawing attention to the advantages of Excello flame lamps for arc lighting. These folders will be supplied gratis to central stations with their own name and address printed thereon.

Showcard.—GENERAL ELECTRIC COMPANY, LTD. This Company's latest "Osram" showcard is of a convenient size for shop windows and show rooms, and has a gauze backing rendering it equally suitable for a dark background or window pane, the letters "Osram Lamps" standing out boldly in either case. Accompanying this showcard is a sheet of testimonials which are interesting reading.

Arc Lamps.—SANTONI ARC LAMP & ENGINEERING COMPANY, LTD., LONDON, E.C. List K-9 illustrates and gives details regarding "Santoni" intense flame lamps, "Perl" enclosed arc lamps, spare parts, auto-transformers, transformer switches, &c.

Trade Notices, &c.

Agency.—MESSRS. CHARLESWORTH, PEEBLES & CO. inform us that they have been appointed for Glasgow and the West of Scotland the sole selling agents of Messrs. Bruce, Peebles & Co., Ltd., East Pilton, Edinburgh.

Contracts Received.—THE MIRRLEES WATSON COMPANY, LTD., have recently received orders for a number of condensing plants, among which are the following: — Borough of Southport, surface plant; Aktiebolaget de Lavals Augturbin, 2 surface plants; Mitsui & Co., 2 surface plants for Kobe Electric Railway, Japan; James Howden & Co., 1 surface condensing plant for the British Mannesman Tube Co.; Blane & Co., Johannesburg, 1 surface plant.

The following letter appeared in a recent number of *The Engineering Review* of New York, and will doubtless be of interest to many readers:—

27, Farringdon Avenue,
London, 1st August, 1908.

EDITOR,
Engineering Review, New York,

SIR,

My attention has been drawn to an advertisement of the Sirocco Engineering Company of New York, appearing on page 87 of your July issue, in which advertisement that Company purport to threaten legal proceedings against anyone purchasing a fan or blower which is of the *drum* or *multiblade*, or *multivane type*, for which *type* of fans or blowers they allege they possess sole rights.

The assertion of the Sirocco Engineering Company reads that:—

> "Any fan or blower of the *drum* or *multiblade*, or *multivane type* is an infringement of our patent rights,"

bue they have every reason to know that they are stating that which is contrary to fact.

As a matter of fact, such *drum* or *multiblade* or *multivane type* fans or blowers are at least forty years old, and therefore no one may now possess a valid patent for such *type*, though certain details in design or construction may be protected. My own company themselves are well-known as makers of such type of fans, for the particular construction of which patents have been granted in practically all civilised countries, and by way of practical reply to the said overbearing and wide-world threats, necessarily including my company's fans as objects for attack, *I challenge your advertisers to make good these threats against us if they can.* If—as they well know—they cannot, it would be wise were they in future to confine their claims to such as may be *validly* made on behalf of their particular form of fan.

It is a curious fact that while the Sirocco Engineering Company, of New York, are the authors of the advertisement referred to, the parent company-owners of the same fan here have never, so far as I know, been so foolish as to publish the same claim in the United Kingdom. Such flagrant misrepresentation of fact, for the evident purpose of intimidation, is very severely dealt with by the laws of the United Kingdom, in which country your journal has a considerable circulation.

I feel sure that, in the interests of the whole world of fan makers and users, you will not hesitate to publish this letter in your journal.

I am, Sir, your obedient servant,

(signed) JAMES KEITH, A.M.I.C.E., M.I.M.E.,

Managing Director of
James Keith & Blackman Co., Ltd.,
London, Manchester, Glasgow, Birmingham, Leeds, Belfast, and Arbroath.

Coal-cutting by Machinery.—To correct any misunderstanding which the author believes may have occurred, readers are advised that the article "Coal-cutting by Machinery," by Mr. A. S. E. Ackermann, in the last number of THE ELECTRICAL MAGAZINE, terminated on page 110.

The

Electrical Magazine.

VOL. X. No. 4. LONDON. OCTOBER 15th, 1908.

The World's Electric Progress.

The Electrical Exhibition.

MANCHESTER has for long enjoyed the reputation of being thorough in whatever scheme of business, pleasure, or progress it may take up, and hence it was generally accepted that, when an electrical exhibition was decided upon and Manchester selected for its location, success was assured. Now that the exhibition is an accomplished fact it shows a perfection even surpassing expectations, and, without exaggeration, it is safe to say that never before has the universal triumph of electricity been so well exemplified. In the exhibition hall there is indeed a concentration of energy, in the electro-technical and personal senses, which it would be difficult to surpass. Nothing seems to have been too much trouble to everyone connected with the bringing together of the exhibition; the management and the exhibitors have laid themselves out to do their best, and the result is an exhibition of electrical engineering work in which the vast scope of modern electrical practice is borne irresistibly upon the visitor.

The most striking feature of the exhibition is undoubtedly the variety of the industrial electric power plants on view; the electric generating side is covered by many examples of high-speed steam sets, turbine sets, gas-electric units, rotary converters, motor-generators, batteries, high-power switch gear, and so on. Of industrial electric power applications there is actual work being done in the spinning and weaving of cotton, wood-working, pumping, and air compressing; there are machine tools of every class, of the heaviest shop patterns and lightest portable types, shown in everyday service. Of course there are innumerable specimens of the art work and novelties demanded by present-day electric lighting to be seen, but these, as is so often the case at electrical exhibitions, are not so much in evidence as to give one the erroneous idea that the electrical business consists mainly of the ingenious and more or less artistic assembly of brass stampings, antique finishes, and cut glass. It is to this unique blending of the largest and smallest of electrical plant and device that the exhibition owes its exceptional charm and value.

To give credit where it is due is to dispense it broadcast. It is particularly gratifying to notice that no fewer than twenty-nine municipalities owning electric supply systems have directly associated themselves with the scheme. This ensures a live and popular interest over a very wide surrounding area, and will undoubtedly result in an immediate boom in the demand for public electric supply service. This direct rate-aided support has, moreover, probably had quite a great deal to do with the encouragement of electrical firms,

influencing them to come forward and take up the exhibition in a whole-hearted manner.

The excellence of the management is evidenced by the full completion of the exhibition by the appointed day of opening; there was nothing lacking, and although the inevitable night and day labour of large gangs of men held sway right up to the eve of opening, when the hour came everything was ship-shape and in running order.

As to the exhibitors, the proof of their labours is the exhibition as it is. In practically all cases, and there are over 250 exhibitors, they have one and all spared neither trouble nor expense; nothing but the very best and most representative exhibit that each could devise was good enough. This keen spirit of rivalry can only have the best of results, and we feel convinced that the enterprise displayed will be reflected in an all-round increase of business.

The exhibition remains open until October 31st, and all who are in any way interested in electrical matters should, if at all possible, see this collection of all that is latest and best in electrical practice. In this connection we should remind readers that THE ELECTRICAL MAGAZINE occupies Stand No. 180, and that our services are cordially placed at their disposal for any information or assistance they may desire.

Kuzel Tungsten Filaments.

A PATENT recently taken out by Hans Kuzel, of Vienna, relates to a process whereby it is practicable to obtain much thinner tungsten filaments than by previous processes. The claims are, first, for obtaining particularly thin filaments by a process consisting in producing a plastic mass containing tungsten and colloidal oxynitride of tungsten, drying the filaments obtained therefrom and finally gradually heating them to a white heat in a non-oxidising temperature; and, second, on a thread capable of being converted into a crystalline tungsten filament and containing tungsten and colloidal oxynitride of tungsten.

In the specification it is stated that according to H. Schulze (*Journal für Praktische Chemie*, XXXII., page 399) colloidal tungsten is obtained by reducing tungstic trioxide with potassium cyanide. But from a paper of Dèsi (*Journal of the American Chemical Society*, 1897, page 239) it is seen that the reaction goes on differently according to the temperature maintained. On the one hand, at the most intense white heat the reaction leads to crystalline or molten tungsten, while on the other hand, when working at as low a red heat as possible, an oxynitride in the form of black powder is obtained, the exact composition of which could not be found. By heating tungstic trioxide with sal ammoniac Dèsi obtained the same oxynitrides, which likewise could not be defined exactly. According to the temperature at which the reaction was carried out the black bodies obtained showed, when analysed, a varying percentage of tungsten, down to 83 per cent. and even less.

The varying results of the analysis might possibly be explained by assuming that when working at low temperatures, besides an oxynitride of a well-defined composition, there is produced simultaneously therewith always a larger or smaller amount of colloidal tungsten. The inventor states that he has found that these black substances containing oxynitrides of tungsten are partly already in the colloidal state, and that they may be readily converted completely into the colloidal state by treating the most finely comminuted substance alternately with solutions of an acid and a non-acid character under thorough agitation, and also heating to a temperature not exceeding 100deg. C.

The object of the present invention is to utilise these black, more or less colloidal, products containing oxynitrides for manufacturing filaments. The substance obtained as above described in a more or less completely colloidal state is worked into a plastic mass in the known manner either by removing therefrom any superfluous imbibition liquid by cautious evaporation, or by pressure, or by incorporating into the substance the

required quantity of imbibition liquid by thorough mixing and agitation or kneading.

From the plastic mass thus obtained threads are made in any known manner, preferably by squirting these threads containing tungsten and colloidal oxynitrides of tungsten. They are then cautiously dried and finally gradually heated to a white heat, preferably by an electric current passed through them. The heating is effected in a non-oxidising atmosphere either in an inert or reducing gas, such as hydrogen or nitrogen, and preferably in the form of a current; or it may be *in vacuo*, the vacuum being maintained as nearly as possible uniform during the heating by means of an efficient pump. By such heating, the colloidal tungsten is converted into the crystalline state and at the same time the oxynitrides of tungsten are reduced to tungsten, also in the crystalline state, so that a filament consisting of pure tungsten in the crystalline state is obtained which is ready for use. This conversion is accompanied by a reduction of the diameter and the length of the filament, this reduction being twice the shrinking of pure colloidal tungsten. By using the black colloids containing oxynitrides of tungsten it is therefore possible to obtain most easily much thinner filaments than by using pure colloidal tungsten. The great shrinkage is fairly well explained by the fact that the colloid containing oxynitrides contains only 83 per cent. tungsten, and that these colloidal threads, as has been shown by experiment, are capable of retaining more imbibition liquid (possibly in the form of gel water, which plays a part similar to that of crystal water) than the colloidal tungsten.

Electric Power on the Rand.

MOST of our readers are familiar with the projected colossal electric transmission which is to have its source in the Victoria Falls of the Zambesi and its distributing network spread over the Rand, of which a full description appeared in THE ELECTRICAL MAGAZINE of December, 1906. Up to the present the endeavours of the Victoria Falls Power Company, Limited, which controls the scheme, have been directed towards cultivating the market for energy in the Rand by means of local power stations, these to be absorbed in the greater final scheme when the demand and profits warrant its installation.

The report of the directors just to hand for the period from the incorporation of the company (October 17, 1906) to December 31, 1907, states that a profit and loss account has not been included, because the year 1907, and also the current year, are, and will be, occupied by the work of construction, during which interest on the preference shares issued in December, 1906, is paid by the British South Africa Company. A revenue and expenditure account is included in the balance-sheet, and £36,686, being the surplus of revenue over expenditure, is carried forward to the current year. The steam-driven 5000h.p. electrical power plant, which the prospectus stated had been purchased from the General Electric Power Company, Limited, was in full work during the whole period under review, and earned satisfactory profits. The supply of the Witwatersrand market continues to be the first object of the company. After full investigation of the local conditions, it was decided to erect a new 8000h.p. station at Brakpan, and a second station of 16,000h.p. capacity at the Simmer Pan, near Germiston, where an excellent freehold site has been purchased, and the required facilities have been granted by the Government. An agreement for an ample supply of water has been obtained on favourable terms, and adequate facilities for the delivery of coal by rail. The directors report that most satisfactory progress has been made in the construction of the new plant. Application is being made to the Transvaal Legislative Council for a private Bill, with the object of placing the company in a position to take advantage of the facilities which it has acquired under its agreement with the Vereeniging Estates and Messrs. Lewis & Marks, in connection with the erection of a power station at Vereeniging, on the Vaal river. The anticipation in the prospectus that the earnings from the existing station of the General Electric Power Company, Limited, would cover the general expenses during the period of construction has been fully realized. These earnings, with those of the Rand Central works, have enabled the company, even during the construction period, to accumulate a substantial fund which is available for the general purposes of the company.

THE SPHERE OF ELECTRICITY IN SHIPS AND SHIPYARDS.

JAMES A. SEAGER, A.M.I.C.E., A.I.E.E.

THE development of electricity in connection with industrial enterprises has, of late years, proceeded at such a rapid rate that it is difficult at times to define the exact position it has attained in any particular direction. More especially is this the case with regard to shipbuilding, inasmuch as designs and methods of working have been largely recast within a comparatively recent period, and the opportunities for the application of electricity have had to be tested and defined. It may therefore be worth while attempting a general summary of the uses of electricity in shipbuilding yards and on board ship, and a deduction as to the probable future needs of the industry. It will of course be impossible in such a broad survey as this to give more than general indications of progress, leaving details to be worked out by specialists in each particular branch.

The natural way in which to discuss the subject is first of all to study the processes which are employed in building a vessel, and then to examine the equipment of the completed ship. We can, therefore, take, first of all, the modern shipyard and see what part electricity plays therein. The chief purposes to which this agent is applied in the yard are: The shearing and punching of the plates, operation of the rolls, plate bending machines and mangles used in shaping the ship's covering, the working of the cranes for lifting the parts of vessels into position, the lighting of the shipyards and temporary lighting on board ships, the operation of slipway haulages, the pumping out of dry docks, and not infrequently the electrical operation of air compressors and hydraulic pumps which are employed on the air and water systems used in riveting and pressing operations. There are also, in every case, workshops both for metals and wood used in construction attached to the yard, and in such shops electric motive power can be and is usually applied.

Taking these operations in order, it may be observed that the manufacturers of plate bending and punching machinery are now in every case prepared to offer standard designs of plant embodying a convenient arrangement for electrical drive, and this indicates the extent to which electrical power has become standard practice in modern ship yards. Many instances have, however, occurred where the conversion of a yard from operation by detached and inefficient steam units to electric power supply from a central source has involved the adaptation of older designs to the new drive, and this is usually accomplished by putting down a concrete base and using belt drive. A good arrangement for vertical plate-punching machines is found in the yard of Swan, Hunter, & Wigham Richardson, Ltd., recently described in *Electrical Engineering;* the plan followed is to mount the motor on top of the casting holding the ram of the punch, and to drive on to the mechanism by belt, providing flywheels of considerable inertia to take the shock of the punch off the motor. Another ingenious drive is the one applied to a counter-sinking machine in the same yards; in this the motor, mounted at the pivot of the jib, is geared into a shaft running along the jib carrying a key way into which bevel gear operating the counter-sink engages by means of a feather key. It will be seen that the conversion of existing shipyard tools to elec-

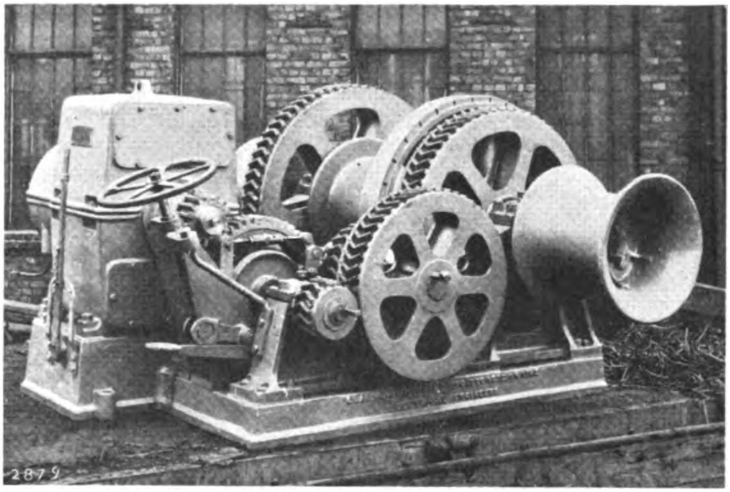


FIG. 1. SHIPYARD WINCH BY CLARKE, CHAPMAN, & CO.

trical drive offers many interesting problems to the electrical engineer. The principal problem, apart from questions of mechanical detail, is that of adequately providing for the great irregularities of load imposed on the motors by the operation of such plant.

The functions of cranes in a shipyard may be divided into two classes, the first being the transport of material from the shops and stores to the ships, and the second being the lifting of plates and beams into position. The older method of carrying the plates to the ship was generally to place them horizontally on bogies running on light wheels throughout the yard, and depending on manual labour to get the bogies from point to point. This was expensive and not infrequently led to accident. Nowadays the plates are usually slung from the jib of a portable crane drawn along the track either by steam or electric power. One of the drawbacks to the use of the latter has been the danger of constructional work fouling the overhead electrical conductors; these should, whenever possible (*i.e.*, at every point except on the actual trolley wire), be rubber covered, and a simple and cheap form of conduit easily installed and altered to suit requirements is urgently required for shipyards. The lifting of plates into position is usually accomplished either by a series of large jib cranes ranged on either side of the boat or by a system of overhead cranes of the gantry or overhead ropeway description. Either continuous-current or polyphase motors have been installed for this purpose, depending on the nature of the supply to the shipyard; the most convenient arrangement is probably that in which cranes, each capable of lifting 4 tons to 6 tons at speeds of 70ft. per minute to 90ft. per minute, can if necessary be combined to lift heavier loads.

Shipyard lighting is a particularly difficult problem owing to the large amount of open space it is necessary to illuminate with a certain degree of uniformity. That trouble has been found owing to this cause is evidenced by the recent communication from the Home Office to owners of shipyards pointing out that during the last three years accidents in shipyards have been on the increase, and drawing attention among other things to the necessity of adequate lighting. Electric light is in this connection considerably superior to the oil flares that are still used on account of the ease with which wiring can be run to any point and the comparative safety of this form of light in relation to workmen. Instances have, however, been known of complaint that the quality of the light given by electric arc lamps is not suitable to penetrate the fogs that frequently occur on the low-lying ground on which shipyards are situated, but this point is disposed of by the use of flame arc lamps. Due regard should be given, when laying down an electric lighting system in a shipyard, to the fact that a supply of current has frequently to be taken on board a vessel in course of construction and connected up to the wiring system on board the boat. For this reason it should preferably have a voltage equal to the usual pressure of supply on board ship, and having regard to the usual requirements, a pressure of 100 volts is found very suitable. Arc lamps can of course be run in series off the power circuits of the shipyard.

Of late years some very good equipments of electrical haulages have been installed in shipyards for the purpose of getting ships into dry dock previous to repair and for warping purposes. A typical two-speed winch

made by Messrs. Clarke, Chapman, & Co., Ltd., of Gateshead, is shown in Fig. 1, and consists of a 50b.h.p. motor driving a barrel and two warping drums by three pairs of spur wheels. Very efficient braking arrangements have to be made in this class of gear, as the damage attending any slip-back of the boat due to failure of current or any other cause would be very great. Both screw-down and post brakes are therefore provided. The winch illustrated is designed to lift 12 tons at 40ft. per minute, or 6 tons at 80ft. per minute, the alteration being made by suitable gearing on the drum shaft. There is also a distinct place for electric haulage in shipyards in the provision of means of opening gates of dry docks, capstans for working goods about the yards, and for use on quay walls where ships have to be drawn from one point to another, &c. It should be noted in this connection that electrical operation provides a means for reducing capital cost, as in contrast with an intermittently-used steam winch there can be installed a crane-rated motor guaranteed to run for, say, one hour at full load with a 100deg. F. temperature rise, and permanently on average requirements.

The development of the large-capacity, low-pressure turbine pump and its application to high-speed electric drive has led to the employment of this means for the rapid emptying of docks as compared with the older-established steam-driven sets. The fact that many pumping stations for this purpose are situated in the dock wall renders them often exceedingly cramped, and the small size of electrically-driven high-speed rotary pumps has led to their adoption, with the elimination of much waste time in docking a vessel owing to the greater capacity of pumping power installed. At first some difficulty was experienced in regulating such low-pressure pumps at the differences of heads inside and without the dock, ranging from nothing to, say, 30ft., but these troubles are now overcome.

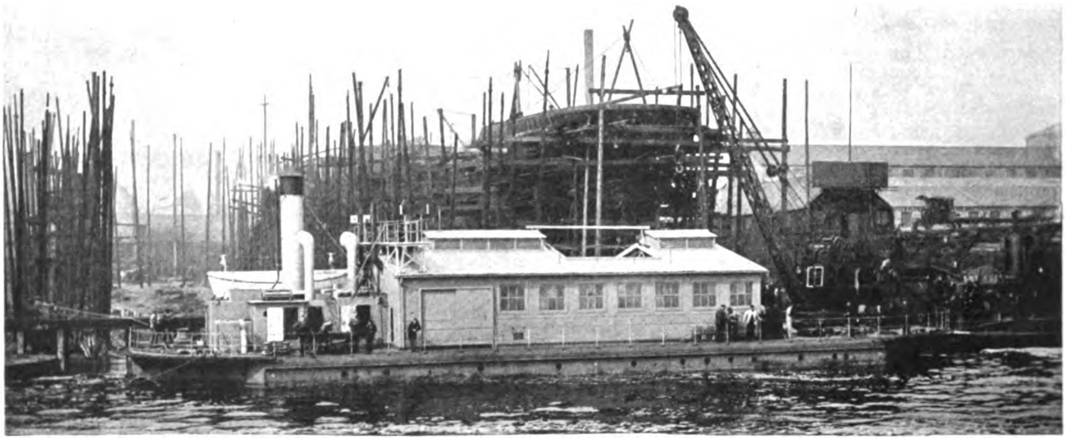


FIG. 2. FLOATING ELECTRIC WORKSHOP SUPPLIED TO THE NATAL GOVERNMENT.

The remaining operations of the shipyard which were mentioned as capable of electrical operation may be dismissed in a few words. The direct application of electricity to riveting, which forms such an important part of a modern shipyard's operations, has been attempted and some very good electrical riveters brought out. Up to the present time, however, it has been found better to turn over the riveting to a compressed-air installation, using the pneumatic tool with which the workmen are familiar, and to drive the compressor electrically. As regards hydraulic plant in a shipyard, this offers the advantage of equal, steady pressure, storage of energy, and ease of operation with an efficiency very comparable with that of electrical working of machinery, so that here again the better course is to devote electricity

to running the hydraulic pumps. The requirements of a shipyard workshop need not be described in detail. Perhaps the most interesting way of showing these is to illustrate a small floating workshop built a little while ago for the Natal Government by Messrs. Swan, Hunter, & Wigham Richardson, Ltd., and fitted with drilling machines, shaper, radial drill, lathe, punch, grindstone, and fan, all driven by Lundell motors, aggregating 24½b.h.p. and operated by a six-pole "Castle" steam-driven dynamo of 53b.h.p., installed by Messrs. J. H. Holmes & Co. The view shows it just after its launch. Many of the workshop processes of a shipyard are carried out on board the vessel after launch, and for this purpose it is convenient to carry an armoured trunk cable on to the ship and tap from this on to suitable power circuits on the vessel. For example, during the construction of the *Mauretania* the work of preparing the decks was much facilitated by means of an electric deck planer somewhat similar in appearance to a lawn mower, which was operated off the ship's power circuit and did away with some very tedious and expensive carpenter's work.

Turning now to the second part of the subject, the electrical equipment of ships, it may be pointed out that the use of electricity for a large number of purposes on board has received the *cachet* of Government approval. The recent "mystery ship" launched at Elswick, H.M.S. *Invincible*, a battleship cruiser of 17,250 tons displacement, is, so far as one can gather, chiefly mysterious in respect to details made for the electrical operation of her auxiliary machinery and armament, which has been pushed to a point not hitherto attained. Naturally, official reticence prevents very much reference to the actual electrical equipment of ships of war, but the chief uses for electricity in this connection may be summarised in general terms as follow: In addition to the operation of boat, coal, ash, and ammunition hoists, capstan gears, fans and pumps, electric circuits are provided for gun and torpedo firing, tiller indicators, stoking indicators, thermometer indicators for the temperature of the magazines, together with transmitters and receivers for range-finding when firing Searchlights are, of course, in extended use, while electric motive power is used in training guns. In addition there are various minor uses, such as fire-control systems, bell installations, pumps, fans, workshop power, and other purposes. Electric lighting is an integral part of warship equipment, from the first-class battleship to the smallest gunboat. On the floating coal depot at Portsmouth, for example, Messrs. Clarke, Chapman, & Co., Ltd., installed 433 lights, two windlasses, and three generating plants of 164kw. each.

The mercantile marine has availed itself of the advantages of electricity to a very marked degree, and boats ranging from ocean liners, such as the recently built Cunarders down to the smallest fishing trawler are equipped electrically. The purposes for which this agent is employed are for electric lighting, searchlight projectors, winches, windlasses, capstans, and other ship deck machinery, coal and boat hoists, lifts on passenger ships, and auxiliary purposes such as bell circuits, signalling gear, and whip hoists for mails. A very interesting paper on this subject was recently read by Mr. W. D. Kirkpatrick before the Liverpool Engineering Society, and reported in the technical papers, and to this paper, together with the portions of the paper on "The Cost of Electrical Power for Industrial Purposes" dealing with shipyard equipments, and read by Mr. J. F. C. Snell before the Institution of Electrical Engineers, the reader may be referred for many useful details and figures.

Before leaving this subject, it is interesting to note the proposition recently made by Mr. H. A. Mavor before the Institution of Engineers and Shipbuilders in Scotland, which, briefly stated, is to use a high-speed turbo-dynamo, three-phase, set to produce power to be transmitted to a motor having a field capable of reversible rotation by means of an auxiliary motor, thus securing three different speeds at which the propeller of a boat may travel with maximum efficiency of the generating plant. This opens up, as a comparatively near thing, and one possessing far-reaching possibilities, the prospect of the application of electricity to the main propulsion of a vessel—a step in advance which will certainly introduce a new and very important opportunity for electrical engineering application.

DEDUCTIONS FROM THE HISTORY OF THE ELECTRIC LAMP.

By A LAMPMAKER.

To the man who can afford time to look back over the records of progress of the past few years, and can bring to the aid of the written pages a memory of the conditions which existed during his own boyhood, few things will be more impressive, will strike him with greater force, or afford him more opportunity for thought than the enormous strides which have been made in the development of the methods of artificial lighting. One is so apt to take each new introduction as a matter of course, after the first gasp of wonder with which it is received has died away, that one omits to notice that it is but a natural development—a development which might have been so easily foreseen, so intelligently anticipated by the student—arising out of some previous discovery, some existing method, forced into growth by some pressing need for improved efficiency, and brought into the world of practical appliances when the hour demanded. A closer examination into cause and effect will show that each method introduced and practically developed will inevitably become, sooner or later, a commercial suicide, and by filling the need which called it into being will create a greater need which will cry out to the student, the inventor, and the engineer, who will in answer promptly either improve that method almost beyond recognition, or strike out on some new line and produce something which will at once relegate the older method to oblivion. The history will then certainly be repeated; the new comer, filling the want, will create fresh business, calling in time for improvements which, in their turn, will be forthcoming in due course. A good example of this can be seen in the history of writing. The chipping on the bone gave place to the scratching on the brick. The possibility of exchange of thoughts with a written record thereof gave rise to a desire for a more simple method, and the brick gave place to the wax and the small stylus. The pen thus evolved developed slowly at first, for it was sufficient to fill the needs for many centuries. Aided by developments in other lines, the quill gave place to the steel pen, cheaper and more convenient in every way. Writing and the exchanging of thoughts were within reach of everyone, and here, as frequently happens, the parent tree threw out a branch and the exchanging of ideas proceeded to develop on its own lines, which, involving such trifles as newspapers and the General Post Office, need not be followed further. The steel pen was unable to cope with the labour demanded from it. The need called aloud, and the mechanical writing machine came, was improved, and developed into the typewriter as we know it. Already there are signs that a newer development still is in preparation, although it would be difficult to forecast its nature. The business carried out by the typewriter has called into existence the mechanically produced imitation-typewritten circular, which will probably be ultimately ousted by the newer ribbon-printed facsimiles which are being turned out every day in hundreds of thousands, each of which could have been produced by the typewriter and is meant to give the impression that it has been produced by the typewriter—the typewriter created a need which it was ultimately unable, unaided, to supply.

Examples of this development, with the

resultant *hari-kari*, will occur to everyone, and it would seem that since nothing apparently has as yet been exempt from what appears to be an inexorable law, our present methods, supplying the needs of the world to-day, will inevitably be driven from the field by reason of the comparative ease with which they perform their task.

Having thus outlined the progress of development in general, it is time to turn to the development of the methods of artificial lighting, and particularly of electric lighting, in order to see whether this development has conformed to the general rule which has been laid down, and whether or not the lines on which future development will take place cannot be forecast with more than ordinary accuracy. A body in motion will continue to travel in a straight line unless acted upon by some other force. If its direction is changed it is not a difficult matter to find the cause of the deflection. If some other body or influence is approaching it, it should not be impossible to foresee how both will be affected should they meet. So with our development. We see the beginning of the progress, which, unacted upon, would continue in a straight line of uneventful evenness. We can tell the influences which have affected it in the past; we can see the effect they have had; we are well aware of the stage which has been reached at the present time, and with the already learned lessons in our mind we should be able to gain some idea of what may be expected, with more or less confidence in the correctness of the prophecy or deduction, to be the developments which will occur in the near future.

A point which is here worthy of notice, and which, curiously enough, has not received that attention from the student, or indeed from the inventor, which it merits, is that there is a strong tendency on the part of the human brain to think in grooves. In some way or other a discovery is made and a method by means of which some pressing need of mankind can be filled is devised. Immediately inventors follow the lead given, and work on the original discovery, adhering to the lines laid down, continuing the development of the first method which was adopted. After a certain, usually a considerable, lapse of time, some genius, by the exercise of original thought, strikes out in a fresh direction and devises some means of a totally distinct character by which the same end can be attained. Or some inventor, with less originality, harks back to the inception of the idea and proceeds to carry out its development along lines of his own, until his efforts are crowned with success, and similar or better results, obtained probably in a commercially cheaper manner, are attained. At once the whole army of what may be termed improvers abandon their previous studies and rush helter-skelter to the new line of investigation. The methods they have been following are abandoned and eventually forgotten, and a new groove is laid down along which each steadily proceeds. Possibly some student, years afterwards, turns back to the point where the previous rut came to a dead end, gives his attention to the old and exploded ideas, sees that some good may result from carrying them further, meets with some degree of success, and immediately the army of workers-up of other men's ideas come back, enthusiastically eager to improve where they have not possessed sufficient knowledge or originality to initiate.

The first experiments in the effort to produce small lighting units by means of the electric current were carried out by means of wires of various metals which were rendered incandescent. There were certain results obtained which to us seem poor, but which were then considered to be of astonishing value. Scientist after scientist carried on the experimental work, until the possibilities of carbon were guessed at, and eventually became known. The results obtained with carbon filaments were far superior to any that had been gained by the use of metals, and all researches into the behaviour of the latter came to a sudden stop, everyone commencing work on the new material. The development of the lamps was crippled to a great extent by the comprehensive patents, until their effluxion allowed scope for research. Then improvements in carbon filaments were eagerly pushed forward, many experimentalists anticipating to some extent the latest developments known and working on a combination of silicon and carbon, boron and carbon, and a mixture of silicon and boron with carbon.

But as a type it was seen that the carbon filament was practically as nearly perfect as human skill could render it. The comparatively low temperature at which carbon volatilised, together with its short life, at any temperature near its volatilising point

limited its efficiency, and the experience of makers had fixed the operating temperature at a figure which allowed an average life of 1000 hours, with an energy consumption in the neighbourhood of 4 watts per c.p. It is an interesting point to note that the efficiency of the carbon lamp at this period of its development was no better, and in the case of certain makes of lamp was actually poorer than the efficiency of several lamps made by Swan, Edison, Sawyer-Man, and others in the early eighties.

Now the competition of the carbon lamp had by this time practically killed the flat-flame gas-burner, which is an illustration of our earlier point that improved methods have a tendency to kill themselves. In this case, which was of murder rather than suicide, the illustration at first sight does not appear to hold good, but considered practically it will be seen that the flat-flame gas-burner had ousted the oil lamp from ordinary town or shop lighting, and by giving a better illuminating effect had created a desire for more light. This desire was met for the time being by the carbon filament electric lamp, with the result that has been noted. For a time the carbon lamp reigned supreme until the gas mantle was introduced, giving a better light at less cost than the ordinary low-efficiency lamp. There were other advantages consequent on the use of electricity which enabled the latter to withstand for a time the attack of the incandescent gas-burner, but as this latter became improved it was evident that unless some improvements were made in electric lighting gas lighting would attain a superior position which it would be difficult to regain for electricity. Indeed, it began to seem as if the electric lamp would follow the flat-flame burner.

Experiments were made in many directions, and it was quickly seen that as a general thing light was required in a downward rather than an upward direction. In private houses or business premises this was quickly recognised. On the work-table, on the reading desk, on the goods before the eye of the public, was where the light was wanted, and as long as there were sufficient rays given off at an upward angle to prevent the ceilings appearing unduly dull the beholder or user would be satisfied. Lamps with silvered or opal reflectors were hastily brought forward and apparently considerably improved the efficiency of the lamp, but the gas mantle steadily gained ground, and lamp makers generally adopted a course which had frequently been suggested to them, and increased the efficiency of their lamps at the expense of their life. The standard lamps were placed on the market with an efficiency of well under 4 watts per candle-power, but with a life of 800 instead of 1000 hours. In addition to this, a grade of lamps was supplied known as high-efficiency type with a life of some 600 hours or thereabouts, and an efficiency of from 3.1 to 3.5 watts per candle-power. These saved the situation for some time, and it will be here observed that the carbon-filament low-efficiency lamp, having served its purpose and created a need for more light at a less cost, had followed the inexorable rule and practically disappeared. The new electric lamps, plus the advantages attendant on the use of electricity as an illuminant, had a serious effect on the gas mantles, which were at best subject to rapid deterioration, and were extremely fragile. In every direction people were discarding the incandescent burner for the incandescent lamp, and gas engineers were working incessantly in the endeavour to find improvements which would increase the life of their mantles and counteract the tendency to depreciation. At length they took a leaf out of the electric lamp maker's book, and realising that people would not mind renewing mantles more frequently if they received the benefit of additional light, they began to overrun, as we may term it, their mantles and place high-pressure gas systems on the market. This competition again had a stimulating effect on the lamp makers, who decided to still further overrun their lamps, and as it was realised that this in itself would be insufficient they produced a lamp which combined the high efficiency of the overrun filament with the already partially exploited notion of improving the downward candle-power at the expense of upward illumination.

The new experiments quickly showed that with the ordinary shaped bulb the early blackening of the glass reduced the effectiveness of the lamp to a considerable degree, and it was realised that a large bulb must be provided giving a much larger surface over which the blackening could take place, thus ensuring that the film of carbon deposited would be proportionately thinner. The brightness of the overrun filament was trying

to the eyes, so the lower portion of the bulb was frosted; but in order to prevent this reducing the downward candle-power a portion of the bulb, carefully calculated as to extent, was left plain, and a suitably shaped opal reflector was provided in order to deflect into a downward direction a large proportion of the rays which would otherwise have been partially lost on the walls and ceiling. The introduction of these lamps under such names as "Radio-lite," "Meridian," and so on was immediately successful, and they commanded a ready sale. Even to-day they are still a popular lamp, many people using them in preference to others, and it will be well to bear this in mind when considering the probable line of development electric lighting will take in the future.

We must now retrace our steps a few years and pick up a line of development which had considerable effect on both the gas mantle and the electric lamp, and which was, curiously enough, an offshoot of both. Experiments with a view to improving the efficiency of the gas mantles had brought to light the fact that many rare earths possessed high illuminating powers, and many attempts were made to work these into filaments for electric lamps. The stumbling-block in the way was their extremely high resistance, but it was found that this decreased rapidly as the temperature rose, and that if this resistance could be reduced sufficiently to allow the passage of an appreciable current the heating effect of the latter would reduce this resistance still further, the filament would throw off a brilliant light, and the resistance of the lamp being still greater, even at a high temperature, than that of a carbon filament, the efficiency calculated in watts per candle-power was higher than hitherto had been deemed possible. Unfortunately the Nernst lamp was imperfect at its introduction in many ways. The filament required an initial heating before it would light up. This could have been done with a match or taper, but such a method was certainly cumbersome, and as it would necessitate the removal of the globe and its replacement after the lamp was alight, it would certainly be the cause of many broken filaments. A heating coil was consequently fitted to the lamp, which was cut out of circuit by an electro-magnetic device as soon as sufficient current was passing through the filament to carry on the work of heating. This miniature cut-out frequently failed, and it was not until recently that the makers announced that they had discovered the reason for this, and were prepared to replace all lamps sent to them for the purpose with new and improved mechanism. It is a question as to what would be the position to-day had the Nernst lamp been as perfect when first introduced as it is to-day. The probability is that whilst it would have militated to some extent against the sale of carbon lamps, the metallic filament lamp would not yet have made its appearance, since the Nernst would have been able to hold its own for some time against the incandescent mantle.

It may be well now to go back to the position of the electric lamp prior to the improvements made upon it by Swan, Edison, and Sawyer, in order that the condition at which it had arrived may be fully appreciated. It must be remembered that at this time the metallic filament lamp was undergoing investigation, and it seemed that it would have no competitor. In 1841 a Cheltenham gentleman named Frederick de Moleyns had filed a specification for a process of producing light by means of a filament of platinum heated to incandescence by the passage of an electric current, the light being further aided by the ingenious but extravagant process of allowing a stream of fine carbon or metal particles to fall parallel with this in such close proximity that they also were rendered incandescent. This was followed by the remarkable work of J. W. Starr, a native of Cincinnati, who not only produced the first true metallic filament lamp, but who also invented a magneto-electric generator with which to produce current for lighting purposes. In the history of electricity are written many tragedies, but surely there are none more striking than the fact that Starr, with a perfect incandescent metallic filament lamp well-nigh within his grasp, should have failed to see how little, comparatively speaking, was yet required, and that almost at the threshold of success he should have died of over-work and bitter disappointment at the early age of twenty-five. There is much that is obscure and vague concerning the manner in which this gifted young American attempted to introduce his lamp to the public, but, as will be seen, there is no doubt as to the lamp itself. Certain facts can be gleaned from a statement made in *Knowledge*, June 30th, 1892, by a Mr. Williams, who appears to have been associated to some extent, but to

what degree cannot be ascertained with any accuracy, in the work. In the first place Starr's patent was taken out by a man named King, and it has been alleged that Starr's troubles were aggravated by an attempt made by King to take the credit of the discovery to himself. This is not apparently borne out by any direct evidence, and it is more probable that Starr did not wish to be known as the inventor until he had brought the lamp to a state approaching commercial perfection. Be that as it may, in 1845 an English patent, 10,919, was issued as "Communicated by a certain foreigner residing abroad" for an invention the nature of which was explained as consisting in "The application of a continuous metallic or carbon conductor intensely heated by the passage of electricity for the purpose of illumination."

In the patent specification both platinum and iridium are mentioned as being suitable for the filament, and in the general description given by the inventor it is pointed out that platinum is probably the more suitable of the two since it has but little affinity for oxygen. On the other hand it is more fusible than iridium. It is curious to note this, as it bears evidence to the fact that Starr had some knowledge of the law that the higher the temperature that can be reached the higher will be the efficiency at which the lamp may be operated. Also during the course of his experiments he must have brought iridium by some means, either actually or very nearly, to its melting-point, which is in the neighbourhood of 2500 C. Evidently, however, he was willing to waive this question of efficiency on account of the fact that platinum was almost as suitable and could be worked with comparative ease into the required form. So far it is evident that Starr had discovered the suitability of metals for the filaments of incandescent electric lamps, but the reader who has followed so far may raise the objection that this lamp was devised for burning in the open air, since one of the reasons for the choice of platinum was that it did not oxidise so rapidly as other metals. But this objection is found from a further examination to be unsound. Starr was seeking, when death ended his labours, to obtain a perfect vacuum. One of the chief obstacles in the way of perfecting his lamp was that he could not by any means known to science at that time get even an approximately good exhaustion of the bulb. His patent went on to state that when carbon was used for a filament instead of platinum or iridium, on account of the affinity this substance has for oxygen when raised to a high temperature, it was essential that both air and moisture* should be kept from it whilst in a state of incandescence, and that to accomplish this satisfactorily it was essential to obtain and maintain a vacuum in which the filament must be placed.

A detailed description of the lamp follows the explanation of the principles on which it was based, and in the absence of accurate or even moderately reliable illustrations one gathers that it consisted of a glass bulb or tube which, after the filament and terminals had been fixed in position, was filled with mercury and inverted, similar to the method of construction adopted with the early barometers. This crude means of obtaining a partial vacuum shows that the necessity for exhaustion was fully recognised by the inventor. Into the top of this tube or bulb a piece of extremely fine platinum wire, or foil, was sealed hermetically, the portion passing through the glass being used as one terminal of the lamp. The other end of the wire dipped into the mercury, which formed part of the circuit, the other terminal being fixed in any convenient position in electrical contact therewith.

A point worthy of notice is that Starr in his patent mentions the use of carbon "pencils" as well as carbon in strip form. He further stated that the most suitable carbon for electrical purposes was that which was found in the interior of gas retorts. He stated that the carbon pencils could be used in the same way as the platinum wires, but that the latter should be used in preference to carbon in places where an intense light was required.

For many years Starr retained his anonymity, and until some time after the filing of this patent it was not known with certainty how far he had gone in his investigations. From the statement in *Knowledge* one learns that his early experiments were with platinum and alloys of platinum with iridium. Owing principally to the difficulty in working this alloy into wires of sufficiently fine diameter, researches were carried out by Starr into the possibilities of making carbon filaments which should be of very small cross section,

* From the use of the word "moisture" it would appear that he had been striving to obtain a vacuum by means of filling a vessel with water and pumping until he had removed this as far as possible.—AUTHOR.

and be at the same time strong enough for the purpose of lamp making.

Mr. Starr's first attempt to construct a carbon filament was by baking a fibre of cane. It is on record that his idea was that the silica therein would fuse, and in that way assist in keeping the particles of carbon from disintegrating. A difficulty was experienced in obtaining filaments sufficiently homogeneous in this way, and ultimately Starr cut gas retort carbon into strips, choosing the hardest pieces for the purpose, and working them down as fine as possible by hand.

In the above description of the incandescent electric lamp of nearly seventy years ago two things must strike the reader apart and distinct from the facts that Starr knew that a vacuum was essential, and that he was aware of the law governing temperature and efficiency. The first of these is that his earliest experiments with carbon were carried out on cane fibres, experiments which were recommenced more than thirty years later by Thomas Alva Edison, who made investigations into the suitability for lamp-making purposes of practically every vegetable fibre known to science. The second is the slight mystery which still cloaks Starr's use of silica. Was his reason really that he felt it might assist in keeping the particles of carbon together? Or had he not anticipated to some extent the investigations of Rudolf Langhans more than half a century later (patent No. 14,850—1894), who used silicon, that non-metallic element of which silica is an oxide, in combination with carbon for lamp filaments. And further, had he not equally anticipated the later principles involving the use of silicon and carbon, which are used in the construction of Messrs. Parker & Clark's Helion lamp?

A few years after Starr, in 1859, some inventor, whose name appears to be lost, had carried the science of lamp-making still further, as in a letter to the *Salem Observer* of November 2nd, 1878, Professor Moses G. Farmer, of the U.S. Naval Torpedo Station, Newport, Rhode Island, wrote:—

> Some few of the citizens of Salem . . . . will doubtless recollect a parlour at 11, Pearl Street, Salem, Massachusetts, which was lighted every evening during July, 1859, by the electric light, and this light was subdivided too. . . . This was undoubtedly the first private dwelling ever illuminated by electricity.

Professor Farmer himself took a keen interest in electrical work, and in 1875 had carried his experiments so far as to enable him to light no fewer than forty-two electric lamps of his own manufacture on a circuit divided into the same number of branches. The current was supplied from a steam-driven generator. Neither the candle-power nor the voltage of the lamps is mentioned, but it is almost certain that these would vary considerably on account of crudities of manufacture.

Some time later M. de Changy, in the pages of *La Lumière Electrique*, stated that he and an old master of his had invented many processes for making both metal and carbon filament lamps as far back as 1838, and he illustrated certain of these in the article. Although we are not dealing further with this gentleman, it is only right to say that his inventions must have been of high merit, since, curiously enough, the lamps he illustrates in France as his own bear a singular and, indeed, striking resemblance to the lamps which were being made in the United States at the date of the article. He appears further to have always been of a shy and retiring disposition, since not only had he refrained from showing any of his lamps in public, but his patent specification, deposited in 1858, is worthless from even an historical point of view, the wording being obscure and practically meaningless.

By the year 1876 there was certainly no novelty in obtaining a practically useful electric light from metallic conductors rendered incandescent by the passage of current obtained either from batteries, or one or other of the numerous magneto or dynamo-electric machines. The difficulty lay in obtaining small candle-power lamps and in operating these singly instead of in series with others, which could be made at a reasonable cost, that would be comparatively economical in burning, and which would have a reasonable life.

The report of the Secretary of the United States Navy in 1876 states that "when either platinum or iridium are rendered incandescent by the passage of an electric current through bars or wires made of either metal a mild and pleasant light is emitted much less contracted and glaring than the light obtained from carbon pencils." The report goes on to say: "Platinum affords about 100c.p. per square inch of surface when heated to within 220deg. C. of the

point of fusion, and a bar or wire of it can be maintained at this temperature for any length of time by means of a Farmer's automatic regulator controlling a suitable current. Iridium from its higher melting-point yields more light per square inch of ignited surface, and can also be readily maintained at any desired temperature below fusion."

It is evident from this that the fusing-point of metals had received considerable attention from the point of view of efficiency; and it may be mentioned here that the "bars" referred to were rather more after the nature of films. In size they appear to have been about 2in. long by ⅜in. broad, whilst they were rolled and beaten down to a thickness of not more than $\frac{1}{300}$in.

It has not been considered necessary to go into the researches of Greener and W. E. Staite carried out with many of the so-called rare metals, nor into the experiments of Petrie with iridium carried out as far back as 1849. All that was necessary to trace the history of the electric lamp as a *metallic* filament lamp up to the years immediately preceding 1880 has been done. It will have been seen that whilst the metal was looked upon as the practical filament, there were already many investigators who were considering the value of carbon. In 1873, a Russian physicist, whose studies had gained a prize from the St. Petersburg Academy, took up the question of electric lighting and made a lamp wherein fine pencils of carbon were incandesced in a vacuum. It was again the fact that the vacuum was not perfect which adversely affected the prospects of the carbon lamp. Following him, Mons. Koun and Mons. Bouliguine constructed lamps of similar types, and with them the carbon lamp as an experiment came to an abrupt end. In 1878 to 1880 the work of Swan, Edison, and Sawyer made it a commercial possibility, and it is worthy of note that Edison first commenced working on platinum and the very rare metals of the platinum group. One of his earlier lamps consisted of a glass bulb about the size of an apple in which was enclosed a spiral of fine platinum wire to the ends of which were attached metal conductors. Another Edison metal filament lamp consisted of a fine platinum wire coiled on a spool of lime or other substance of a similar nature, supported on a small rod of the same material. This was enclosed in an exhausted globe. This lamp was noticeable on account of the fact that it was provided with two globes, the outer containing air. The lamp was used in connection with a small auto-controller. When the voltage was high and the lamp was overrun, the heat caused the air to expand, and this acted upon a lever through an ingenious arrangement, which cut off the current until the lamp cooled down.

But by 1879 Edison was hard at work on filaments of paper and thin cardboard, hard at work on all manner of vegetable fibres, hard at work on any and every conceivable substance which might be formed into a carbon filament which would not disintegrate under the influence of the electric current. Sawyer, in conjunction with his partner Man, was hard at work in a similar manner. Swan, who had, in the early sixties, sought to construct an incandescent lamp consisting of a small spiral of carbonised paper joining two carbon blocks in the interior of a glass tube, in which he had laboriously created a vacuum by such crude means as were at his disposal, was working, with success just fluttering within his reach, on filaments of specially treated cotton. The scientific world was intoxicated by the glamour of the carbon filament, and platinum, iridium, and the other metals were discarded, it was felt, for ever. The carbon groove, having commenced, was destined to proceed in the manner we have shown, for almost thirty years.

In 1878 Tyler took out a provisional patent involving the use of platinum, and in the same year St. G. L. Fox obtained numerous patents, one of which was for an incandescent body of platinum, iridium, *or any other wire*, whilst in 1879 Fox mentions the use of zirconia (Patent No. 1122, 1879). In the same year Edison experimented with ceria as well as zirconia, and in 1880 Clingman is also suggesting the use of zirconia with silica. In the same year a remarkable patent was taken out by Fitzgerald, wherein he protected the method of treating an ordinary carbon filament with a solution containing salts of refractory metals, as platinum or iridium, and decomposing them. He further suggested that the whole surface of a carbon filament might be coated with platinum or iridium by *electro-deposition in an inert gas.* Edison, in 1881, possibly in some moment of doubt as to the ultimate success of carbon, proposed filaments composed of zirconium, silicon, boron, pulverised graphite, &c., pressed hydraulically into sheets from which filaments

could be cut. In 1881 Hallet obtained a patent for coating a carbon rod with amorphous silicon. In 1882 Williams formed a filament by depositing a metal or alloy of two metals (not specified) upon a layer of carbon with or without a support of zirconia or other earth. He suggested the use of ruthenium as well as platinum, iridium, and manganese. In 1882 Zanni proposed that a silk, cotton, or other thread should be bent to shape and carbonised, and then coated with platinum or iridium, depositing a final layer of carbon by flashing in a hydro-carbon gas. Hamilton, in 1883, impregnated carbon filaments with strontium or barium, afterwards treating them with platinum and ammonium chlorides. Proceeding in chronological order, we find Dick, in 1885, taking out a patent which is of great interest, although it did not deal with metallic filaments, but with a means of filament-making by which carbonaceous material was inserted in a tube of copper or metal, drawn through dies, rolls, &c., to increase the density, cut into lengths, shaped, carbonised, and the metal then removed by suitable solvents. In 1888 Rudolf Langhans took out patents dealing with silicon combined with carbon filaments, and in 1889 a patent taken out by Edmundson dealt with a process for combining metallic chromium with carbon.

The year 1889 stands out prominently in the history of electric lighting from the point of view of the student, for it was in this year that the use of tungsten for the production of a tungsten filament was first proposed. A certain scientist appears to have followed an independent line of thought and hit upon the substitutional method of filament-making in a somewhat similar manner to the method used to-day. A carbon filament was soaked in a solution of tungsten trioxide, dried, heated, and rendered incandescent in pure hydrogen, thus reducing the tungsten to the metallic state. The same experimentalist also produced filaments by the electrical deposition of tungsten. In 1890 Messrs. Siemens & Halske made further investigations into the behaviour of silicon with carbon, and three years later Placet and Bonnet made a series of experiments with chromium electrically deposited on carbon filaments. In 1894 Langhans took out a further patent covering the use of carbide of silicon and carbide of boron for filament-making purposes. From this date to 1897 one or two investigated further into the properties of silicon and chromium combined with carbon, and in the latter year the Nernst patents were applied for, and the majority of those who had been more or less casually exploring the disused workings in the field of metals turned their attention to the new lamp.

And now we have reviewed the development of the carbon filament lamp from the date when it became commercially possible. We have followed the course of the conflict between electric lighting by its means and gas lighting. We have seen the continued supersession of older types by newer and more perfect methods. We saw the Nernst come into the field, electrically speaking good, but mechanically weak, and there we left our study of the evolution of modern lighting. We went back to the early experiments in metals, followed them to the point where they were abandoned, and have glanced at the workings of the very few who retained their faith, at least to some extent, in the future of the metal filament. And at length we reached the period when everything coalesced, and the more or less desultory and disconnected experiments with one or other of the rare metals gave place to a scientific investigation of their possibilities. The need for an improved form of electric lighting device had almost arrived, and already scientists were making determined efforts to produce a high-efficiency long-life lamp which would be as superior to the carbon filament lamp as the incandescent mantle was to the flat-flame gas-burner.

The first to meet with tangible result was Carl auer von Welsbach, who filed his first patent in this direction in 1898 for filaments made from osmium, or alloys of this with ruthenium, rhodium, or other metals of the platinum group, and almost immediately he was followed by others who were working on thorium, cerium, uranium, ytterbium, zirconium, iridium, titanium, chromium, tungsten, molybdenum, tantalum, &c., and a large number of patents were taken out before the end of 1900.

Amongst these were certain specifications of Dr. Just, which have since passed into practical operation, and closely following this date came the numerous patents of Messrs. Siemens relating to the method of working tantalum.

Everyone knows the result of these labours. When the hour came the new lamps were

commercially possible, and the efforts of the early metal workers, driven from their labours by the carbon lamps, were at last vindicated, and the first metal lamp, with an osmium filament, frail and fragile, and yet big with possibilities, was seen in street lanterns and in a few shops. How long ago was this? Only a few months ago, and since then the metallic filament lamps have leaped into popularity, and, more than that, have won their place by sheer merit rather than by the loud voice of advertisement. The lamps appear to be in bewildering variety, but it is not so; so far as can be ascertained they are of two, or at most three, distinct types. The one type has a filament of tantalum, the other a filament of wolfram or tungsten. It is also probable that there are lamps on the market which have a filament composed of tungsten alloyed with some one or other of the same metallic group. The tungsten lamps, which, judging by the names seen in advertisements, are of numerous makes, are, as a matter of fact, of very few types. The methods of working tungsten seem briefly the substitutional method of Dr. Just and Franz Hanaman, the colloidal method of Dr. Kuzel, the squirted methods followed by more than one manufacturer wherein finely divided tungsten is mixed with an agglutinant, and the squirted amalgam method. It may be said that since there are so many lamps of different names there are probably more methods of manufacture than those mentioned; but as far as the writer is aware this is not so. The impression probably arises from the fact that many of the lamps on the market under different names are really identical, being made by the same processes in the same factory by the same maker.

And now what will be the lines on which electric lighting will proceed? With the metallic filament lamp and the great possibilities before it there seems one thing which is clear. The introduction of the highly improved gas mantle with the improvement of systems of gas lighting filled the need for a better light and created a need which they were unable to supply. Modern necessity called aloud and the metallic filament lamp came into being, to take the place of gas, the suicide. For the first time in the history of electric lighting can the boast of "Electricity cheaper than gas" be made uncontradicted. For the first time price is of more importance than light. Formerly a certain light was required and the price had to be paid. To-day the householder can be lavish, be extravagant with light, and all that governs his desires is the question as to whether he shall save practically three-quarters of his previous electricity account and have the same light, or save less for more illumination, or whether he shall spend the same sum and revel in brilliance. To-day candle-power is a secondary consideration. Lamps are bought by their current consumption; no one cares about the light—the light is always ample. A 30-watt lamp will sell better than a 35-watt, a 16-watt would sell better than either. The field of private business and street lighting is for electricity as soon as station engineers can see themselves or persuade their committees or directors that all superfluities must be removed from the supply system. Meters, elaborate house services, everything that restricts or tends to restrict the use of electric energy should be thrown on one side, and electricity supplied to the householder with no more restrictions than is to-day placed on his water supply.

There is one other point to be considered which follows upon the economy of the lamp as regards current consumption and the cheapness of the lamp as regards manufacture. After the first stage has passed and the factories are in working order, with employees fully accustomed to handling the delicate filaments, metallic filament lamps will be obtainable no doubt more cheaply than at present, and the result of this will be that in business premises, for advertising reasons, a lavish use of electricity will be made. Competition will drive this lavish use still further, and streets and shops will become so brilliant that a revulsion will inevitably set in. In the course of a few years householders will most certainly go back to the quiet, restful carbon filament lamp, and there will once more be a large and steadily growing demand for the "Radiolite" and other kindred types, much as to-day the householder does not buy the cheapest, strongest chairs he can obtain for his dining room, but, if he is able to afford it, goes back to the old designs which sufficed his forefathers, and takes pride in and comfort from his choice. Much as to-day we far prefer the delicacy of the wax candle for our dining rooms, so to-morrow shall we return to the Huntalite candle tubes and the frosted carbon lamp for domestic illumination.

THE TESTING OF ROTARY CONVERTERS.

J. W. ROGERS.

As an introduction to this subject, it will not be out of place to mention a few elementary facts connected with the theory and working of converters so far as the ratio of the voltages and currents in the windings are concerned, the general principles underlying their construction being too well known by readers of this journal to require repetition here.

As is well known, the effective voltage of the A.C. side of a converter $= \frac{1}{\sqrt{2}}$, or .707 times the D.C. voltage for a single-phase converter; also the effective A.C. voltage with a three-phase converter = D.C. volts $\times \frac{.707 \times \sqrt{3}}{2}$ = D.C. volts × .612. The true conversion ratio depends upon (1) the flux distribution over the armature periphery; (2) the power factor; (3) the ratio of the pole-span to the pole-pitch. It also depends to some extent on the position of the brushes on the D.C. side, which should always be fixed in the neutral position.

The ratio of the continuous current to the line currents on the A.C. side of a converter is the inverse ratio of the voltages, assuming the converter losses are negligible and the power factor is unity. The input and output watts would under these conditions be equal, in which case the product of volts × amperes on the A.C. side = product of volts × amperes on the D.C. side, and as the ratio of the alternating to the direct-current voltage is .707 : 1, or 1 : 1.414, then the value of alternating amperes = 1.414 continuous amperes.

Let E and C represent the voltage and current respectively on the D.C. side; also V_1C_1, V_2C_2, and V_3C_3 the voltages and currents on the A.C. side of a single, two-phase, and three-phase converter respectively: then by equating the direct and alternating-current powers and assuming unity power factor we get: $EC = V_1C_1 = 2V_2C_2 = \sqrt{3}V_3C_3$, and since a reference to the voltage ratios shows $V_1 = .707E$, $V_2 = .707E$, and $V_3 = .612E$, then the ratio of the currents on the A.C. side is given by $C_1 = \frac{1}{.707}E$, $C_2 = \left(\frac{1}{2} \times \frac{1}{.707}\right)E$, and $C_3 = \left(\frac{1}{\sqrt{3}} \times \frac{1}{.612}\right)E$. The ratio of the currents may therefore be tabulated as follows :—

Continuous Current.	Alternating Line Currents.		
	Single-phase.	Two-phase.	Three-phase.
100	141.4	70.7	94.3

The following table represents the ratios of the currents and voltages, also the angle between the slip-ring connections obtained with different converters, but the value of these ratios must be taken as purely theoretical, as they are seldom realised in practice, owing to the fact that they do not take into account the effects of (1) armature impedance, (2) power factor, (3) wave form :—

Nature of Current.	Number of Slip Rings.	Angle between Slip-ring Connections.	Voltage between Slip Rings.	Amperes at Slip Rings or Line Current.
Direct	—	—	1	1
Single-phase	2	180°	.707	1.414
Two ,,	4	90°	.707	.707
Three ,,	3	120°	.612	.943
Three ,,	6	60°	.612	.943
Six ,,	6	60°	.354	.472

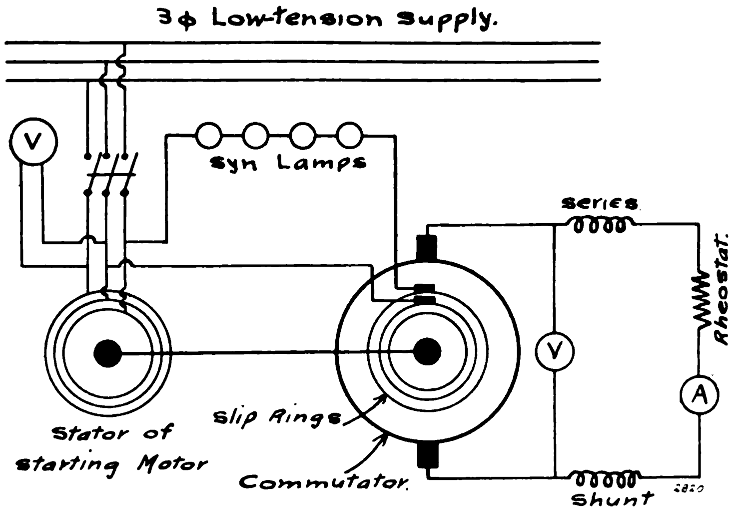


FIG. 1. CONNECTIONS FOR SYNCHRONISING TEST.

than they would be in the case of separate machines of equal outputs.

Considering the case of an inverted rotary when such a machine is running with no-load on the A.C. side its performance is simply that of a direct-current motor, but a load on the A.C. side will have a similar effect as in the case of a converter of the first type, inasmuch as the resultant armature current flowing at any instant will bear the same relation to the direct-current input and the alternate-current output.

As is well known, converters may be divided into two distinct classes, viz., (*a*) machines converting from alternating to direct current; (*b*) machines converting from direct to alternating current, which are known as inverted rotaries.

Machines of the first class are more often met with in present-day practice although the same machine may be worked in either way as occasion demands, the construction being the same in each case. The distribution of the currents in the windings of both types may be considered as follows.

Taking the case of a converter transforming from alternating to direct current, the machine will be running as a synchronous motor and loaded as a direct-current generator. Now the direction of the flow of current in the armature coils of either a direct or alternating-current machine is in the opposite direction, when the machine is working as a motor, to what it would be when the machine was driven as a generator. So it will be easily understood that the current flowing in a coil of a converter armature at any instant will be equal to the difference between the current flowing when the machine is running as a loaded synchronous motor, and the current flowing when the machine is driven as a loaded direct-current generator, the input and output currents being the same. As these currents oppose each other the resultant current in a converter armature is very small and as a consequence of this the armature reaction and heating in a rotary are much smaller

As regards the power ratings for both types of machines, this depends to a great extent on the heating of the converter armature, which is by no means uniform, for the following reasons. It has already been stated that the individual conductors on a converter armature only carry the difference between the motoring and generating currents, and the value of the current flowing in a given conductor will depend upon the position of the armature and also on its position in relation to the slip-rings, so that the actual current flowing in the armature is not equal in all the conductors. For instance, the currents in the conductors which are adjacent to the slip-ring connections would be greater than the currents in the conductors more remote, because the alternating current does not continuously pass through the whole of the armature winding, but flows from the direct-current brushes through a portion of the winding to the slip-rings, so that the portion of the winding nearest the slip-rings will carry the larger current, consequently the heating effect is not evenly distributed among the different conductors. It will therefore be seen that the heating of a converter armature is a rather complicated question to consider, as it varies according to the position of a coil in relation to its connection to the slip-rings, the greatest heat being generated in those conductors nearest the slip-ring connections. The output of a converter depends upon

the temperature rise and increases with the number of slip-rings; the relative power ratings for a given temperature rise of any particular machine when running under different conditions as regards the phase of the current generated are as follows :—

Continuous Current	100
Single-phase	85.2
Three-phase	133
Four-phase	162.5
Six-phase	193

It will be seen from this list that there is a wide variation in the output of the machine when working under the different conditions although the temperature rise does not change; it follows, therefore, that there must be a variation in the resultant currents in the armature winding. The ratings in the above list are based on unity power factor, but for lower power factors the ratings will be reduced; also, a decrease in the power factor will increase the heating when the converter output is held constant. From the list it will be seen that the resultant or equivalent currents in the armature winding of a particular machine for different phase conversion will be as follows:

$$\text{Single-phase} = \frac{1}{.852},$$

$$\text{three-phase} = \frac{1}{1.33}$$

$$\text{four-phase} = \frac{1}{1.625},$$

$$\text{and six-phase} = \frac{1}{1.93},$$

and simplifying these values gives :

Direct Current	1
Single-phase...	1.175
Three-phase	.75
Four-phase	.62
Six-phase	.515

Having briefly considered a few facts connected with the working of converters reference will now be made to the shop-tests carried out on the same, which may be classified under two distinct heads, viz. :

Experimental and Commercial Tests.

Experimental tests are carried out on all machines of new design for the purpose of obtaining information dealing with their performance under test, and also to prove accuracy in design. The tests required for this purpose are (1) resistance, (2) short circuit, (3) iron loss, saturation and friction, (4) efficiency and compounding. The usual methods of conducting these various tests

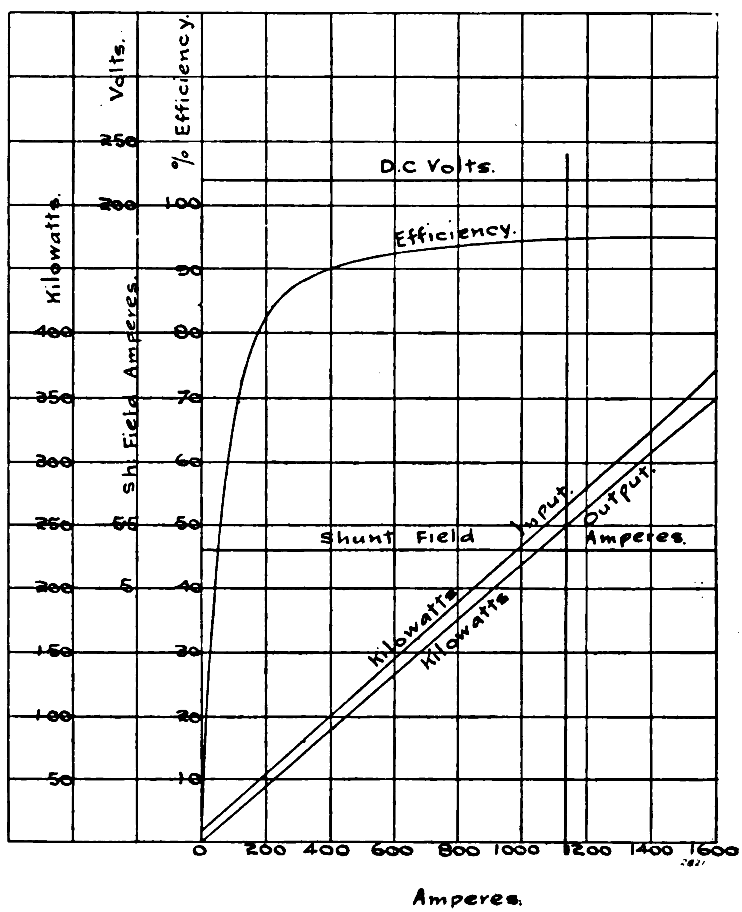


FIG. 2. 250KW. TWO-PHASE ROTARY CONVERTER.

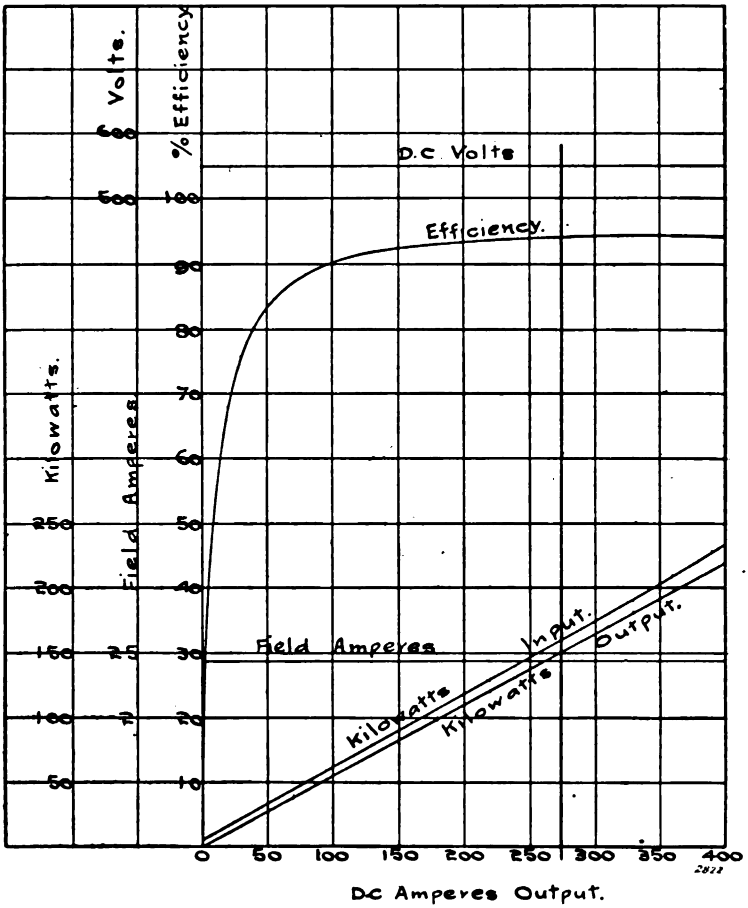


FIG. 3. 150KW. THREE-PHASE ROTARY CONVERTER.

will now be considered. As the three-phase converter is the machine generally met with in present-day practice, the following data will refer more particularly to machines of this type, although the other types have much in common so far as the tests to which they are submitted are concerned.

Resistance Test.

This test is generally carried out on both sides of a converter, but it is quite possible to calculate the resistance of the A.C. side from the results of the resistance measurement on the D.C. side when the type of winding is known. When it is required to measure directly the resistance of the A.C. side this is taken between terminals, and then the total resistance of the three-phase winding (which is always connected in mesh) is equal to $\frac{3}{2} \times$ measured resistance between terminals, because the resistance as measured between terminals is the resultant of one phase in parallel with two phases in series. As a converter is usually compounded it is necessary to measure the resistance of the series winding as well as that of the armature. The resistance of the armature is chiefly required to enable the resistance drop to be calculated, but strictly speaking it is not correct to calculate the drop of a converter armature in this manner for the following reasons: (1) The current flowing in the armature is not equal in all the conductors; (2) the volts drop in the armature is caused by the armature impedance and not only its ohmic resistance; in other words the reactance drop should be taken into account especially when the converter is transforming from alternating to continuous current; (3) the volts drop in the armature depends on the power factor for its phase relationship to the volts impressed on the A.C. side of the converter, and is in almost direct opposition when the angle of lag is large.

Short Circuit.

This test is made on the direct-current side to test the commutation in a weak field. It is carried out by belting the machine to a shunt motor and short-circuiting the armature through an ammeter. The converter is then run up to its normal speed with its field separately excited, the exciting current being gradually increased until the armature current reaches its full load value.

The short-circuit test is carried out on the A.C. side by short-circuiting the armature

through an ammeter of negligible inductance. The readings taken are those of armature amperes, field amperes and kilowatts, the short-circuit characteristic being represented by curves, having armature amperes as abscissæ and field amperes and kilowatts as ordinates.

Iron Loss, Saturation, and Friction.

This test is generally carried out in the same manner as in the case of an alternator, which has already been described in these columns.* As regards the saturation test it is necessary to measure both the alternating and direct-current voltages, so that there will be two separate saturation curves, from which the average value of the voltage ratio may be calculated by reading off the curves the values of the A.C. and D.C. volts for the same value of exciting current.

Compounding and Efficiency.

The compounding test, which is really a form of regulation test, is made to show the relation existing between the kilowatts output and the terminal volts on the direct-current side.

When making this test in the usual way it is necessary to provide inductance on the alternating side, but the most satisfactory method is to run the machine with a constant field strength so that the generator voltage will increase with the load current.

The efficiency of a converter may be obtained by (1) a full-load test, (2) calculation from the losses. The first method, which is only possible in the case of small machines, is made by running the machine on full load with a power factor of unity (which must be held constant throughout the test by adjusting the excitation) and measuring the A.C. input and the D.C. output, the efficiency being the ratio of these two quantities.

When the efficiency is worked up from the losses these are calculated for different outputs on the D.C. side, the efficiency being given by $\frac{\text{output}}{\text{output and losses}}$.

The copper loss is calculated for values of equivalent currents and not the load current as in the case of a D.C. generator.

As regards the commercial tests carried out on converters, these are made to locate faults in the construction of the machines, due to bad work or defective material. The tests generally made are those of (1) polarity; (2) temperature; (3) synchronising; (4) insulation.

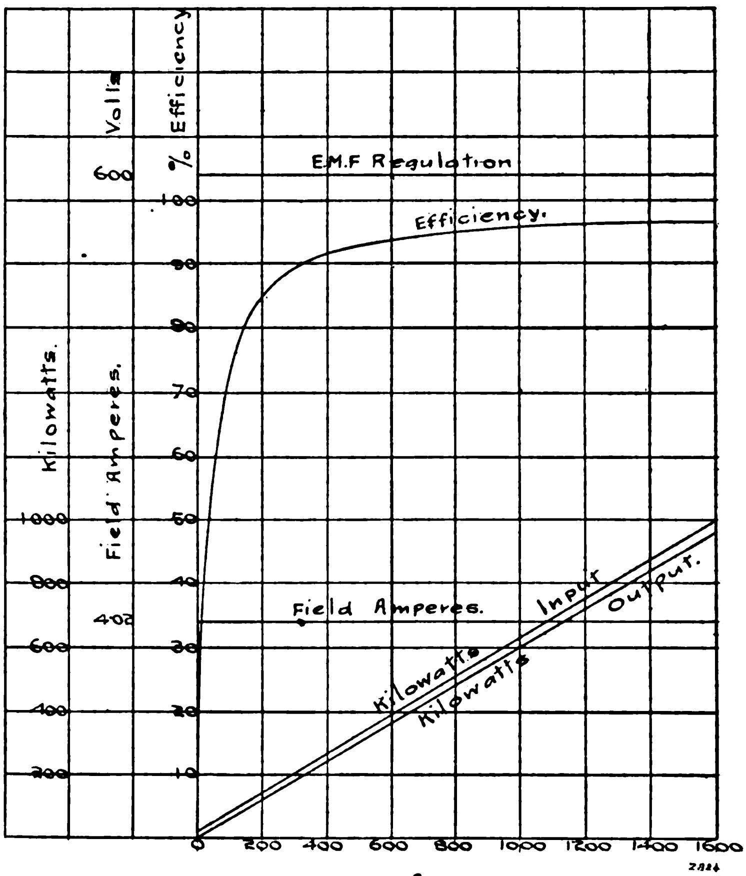


FIG. 4. 600KW. SIX-PHASE ROTARY CONVERTER.

* THE ELECTRICAL MAGAZINE, September, 1908.

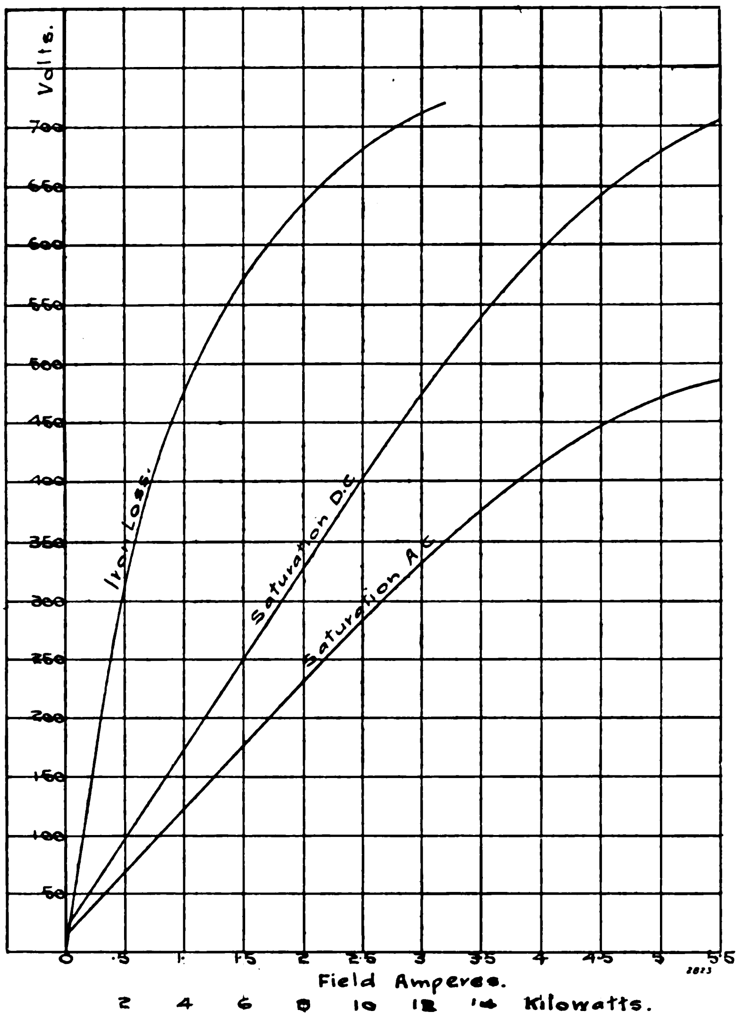


FIG. 5. 600KW. SIX-PHASE ROTARY CONVERTER.

Polarity.

This test is made by exciting the field with a weak current and noting the behaviour of a compass needle when passed from pole to pole. In the case of correct polarity adjacent poles would have a reversed effect on the compass needle.

Synchronising.

This test is made to obtain data showing the conditions under which a converter may be synchronised with the line, when started up from the A.C. side by means of its starting motor, and the diagram of connections for this test is shown in Fig. 1. The test is started by switching the starting motor on to the A.C. supply, when it should run up to a speed slightly higher than the synchronous speed of the converter until the D.C. voltage is built up. When this voltage has reached its normal value, the speed will have decreased nearly to that of synchronism, and as a consequence of this the pulsations of the lamps will become slower. When the exact moment of synchronism is reached, as indicated by the lamps becoming dark, readings are taken of the shunt-field current, D.C. voltage, and the terminal voltage on the starting motor.

Before starting this test the brushes on the D.C. side should be set on the neutral position, and the voltage required to start the starting motor with the shunt field of the converter open should be noted, as this serves as a check on the friction losses.

Temperature.

The temperature test generally takes the form of a full-load run in the case of small machines, but in the case of large machines they are run short-circuited on the D.C. side, with the field separately excited with a weak current sufficient to give the full-load armature current. This test is followed by running the machine on open circuit with its own excitation, the exciting current being in excess of its normal value. The temperatures taken are those of (1) armature winding, (2) armature core, (3) field windings, (4) commutator and slip-rings, (5) atmosphere.

Insulation.

This test, which is made at the conclusion of a temperature run, consists in applying an

alternating voltage equal to double the working voltage, between the armature and field windings and the frame of the machine.

Having briefly described the shop tests generally carried out on converters, perhaps the following curves, which represent the performance of different types of Westinghouse converters and also particulars of some of the tests carried out on the same, may be of interest.

The curves shown in Fig. 2 represent the performance of a 250kw. two-phase, compound-wound converter. The vertical line drawn through the curves represents the full-load point on each curve, and enables the performance of the machine at full load to be read off at a glance. The losses at full load, which is equal to 250kw. ÷ 220 volts = 1135 amperes, are as follows:—

C^2R loss in armature = 1820 watts.

C^2R loss in series field = 585 watts.

C^2R loss in shunt field and rheostat = 1166 watts.

C^2R loss in brushes = 2170 watts.

Iron loss, friction and windage = 8300 watts.

∴ Total losses = 14,041 watts.

Output = 1135 × 220 = 249,700 watts.

Input = output + losses.

= 249,700 + 14,041.

= 263,741 watts.

∴ Efficiency =

$$\frac{249{,}700}{263{,}741} \times 100$$

= 94.75 per cent

At the conclusion of a seven hours' temperature run at 1160amp. and 220 volts, the temperature rise on the various parts of this machine was as follows:

Armature copper = 20deg. C.
Armature iron = 23deg. C.
Shunt field = 24deg. C.
Commutator = 34.5deg. C.

In Fig. 3 are shown the performance curves of a 150kw. three-phase, 550-volt compound converter. The losses at full-

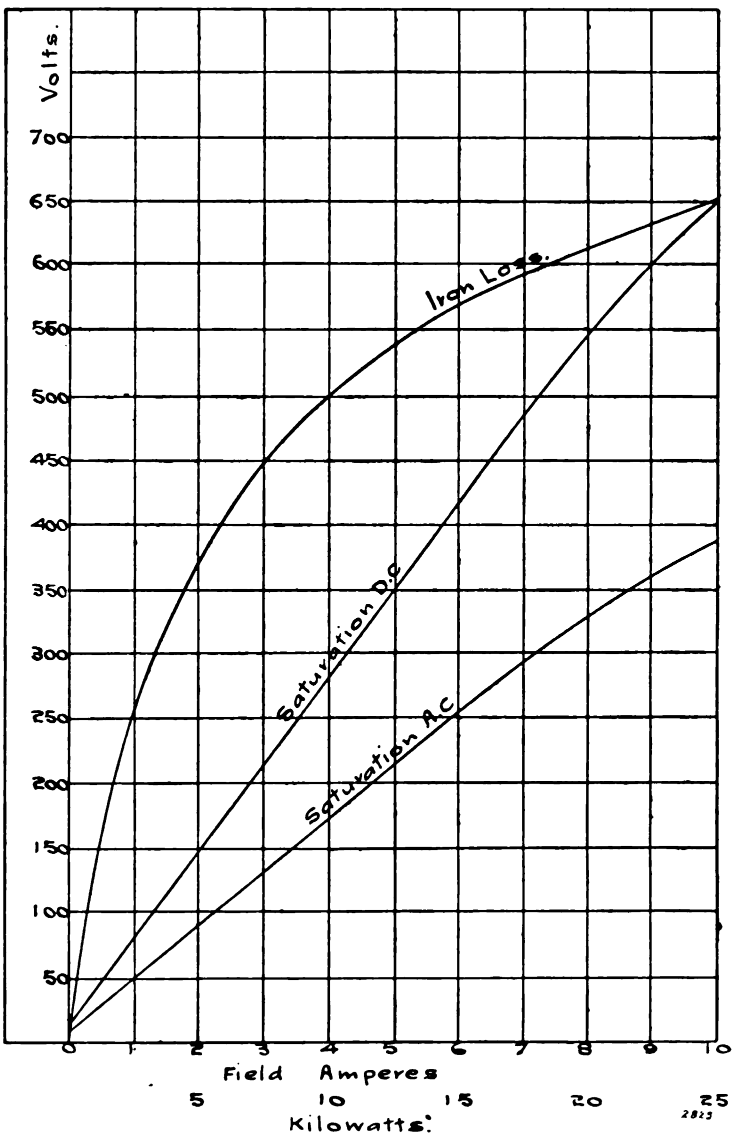


Fig. 6. 1500kw. Three-phase Rotary Converter.

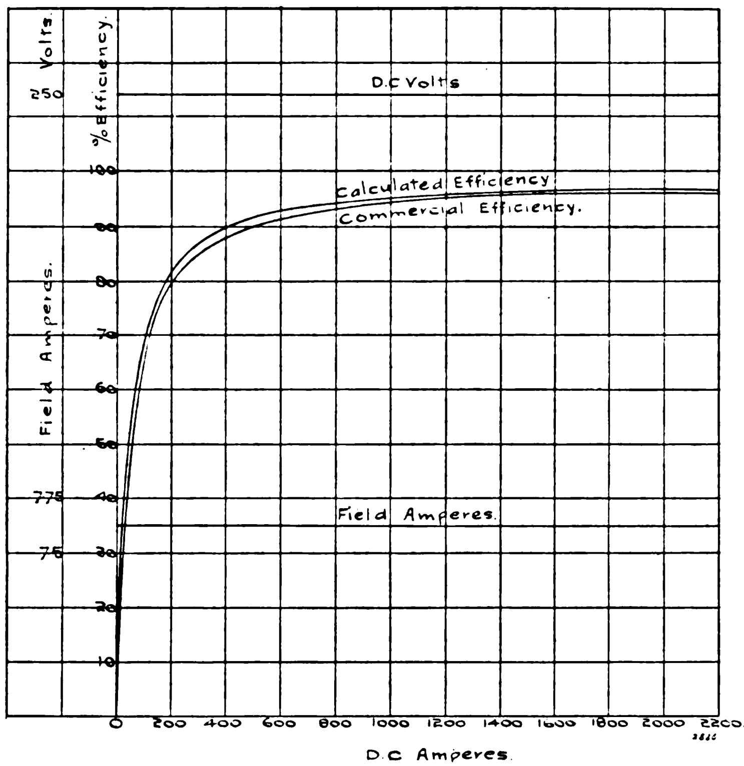


FIG. 7. 350KW. SIX-PHASE ROTARY CONVERTER.

The curves in Figs. 4 and 5 represent the performance of a 600 kw. six-phase converter coupled to a booster set. From the saturation curves in Fig. 5 the average value of the voltage ratio may be calculated by reading off the values of the A.C. and D.C. volts for the same value of exciting current. When calculated in this manner the mean value of the voltage ratio of this machine works out at .696, corresponding to the theoretical value of .707, which represents the voltage ratio of a six-ring converter supplied with current on the alternating current side from three transformers connected across three diameters.

load, which is equal to 273amp., are as follows:

C^2R loss in armature = 2627 watts.
C^2R loss in series field = 634 watts.
C^2R loss in shunt field and rheostat = 1347 watts.
C^2R loss in brushes = 516 watts.
Iron loss = 1910 watts.
Brush friction, friction and windage = 2000 watts.

∴ Total losses = 9034 watts.

Output = 150,000 watts.
Input = 159,034 watts.

$$\text{Efficiency} = \frac{150,000}{159,034} \times 100 = 94.3 \text{ per cent.}$$

The temperature rise on the various parts of this machine after a six hours' run at 275amp. and 550 volts was as follows:—

Armature copper = 25deg. C. rise.
Armature iron = 18deg. C. rise.
Shunt field = 23.5deg. C. rise.
Commutator = 17deg. C. rise.
Collectors = 19deg. C. rise.

The synchronising data of this machine are given in Table II., and the information to be derived from it serves as a guide to the operation of synchronising the machine.

TABLE II.

MOTOR.	ROTARY.		
A.C. Volts.	D.C. Volts.	Field Amps.	Load Amps.
219	665	5.475	—
217	623	4.575	6.5
230	655	5.08	6.6
201	550	3.54	5.25

The resistances of this machine as taken at 17deg. C. are given by armature = .00783ω, series field = .000,727ω, shunt field = 88.93ω.

The losses at the full-load point, 600kw., corresponding to 1000amp. and 600 volts, are as follow:—

C^2R loss in
 Armature ... = 2680 watts.
 Series field ... = 828 ,,

Shunt and rheostat	=	2412	watts.
Brushes	=	1924	„
Booster A.C. winding	=	1332	„
Brush friction... ...	=	5510	„
Iron loss	=	6750	„
Friction and windage	=	5756	„
Total losses ...	=	27,192	„

Watts output = 600,000 watts.
Watts input = 627,192 „

$$\therefore \text{Efficiency} = \frac{600,000}{627,192} = 95.7 \text{ per cent.}$$

In Fig. 6 are shown the iron loss and saturation curves of a 1500kw. three-phase converter. The mean value of the voltage ratio as calculated from these curves works out at .608, corresponding to a theoretical value of .612. The synchronising data of this machine are given in Table III.

TABLE III.

Motor.	Rotary.	
A.C. Volts.	D.C. Volts.	Field Amps.
355	657	9.72
365	680	10.7
378	705	11.2
388	717	11.6

The curves in Fig. 7 represent the calculated and commercial efficiencies of a 350kw. six-phase converter. The calculated efficiency takes into account the C^2R losses in the armature and series and shunt fields, also the iron, friction and windage losses, but the commercial efficiency takes into account the C^2R loss in the brushes, and losses in the shunt field rheostat and German silver shunt to the series field, also losses in the connecting gear, in addition to the other losses mentioned above.

In conclusion the writer's thanks are due to the British Westinghouse Company for their kindness in supplying the curves illustrating this article, and also much data dealing with the testing of their converters.

THE NEW ATLANTIC, *begun by Lord Verulam Viscount St Albans, and continued by R. H. Esquire. London. printed for John Crooke at the Sign of the Ship in St Paul's Churchyard* 1660, contains the following:

Hereupon he immediately reached forth of a little Ark wherein many rarities were placed, a Loadstone far bigger than that which holds up Mahomets tomb in Mecha. This is the truly precious stone of such divine use that by its charitable direction it not only ciments the divided world into one body politic, maintaining trade and society with the remotest parts and Nations, but is in many other things of rare use and service.

I shall not open all its properties most of them being already known amongst you Europeans. I will only unfold this useful and most admirable conclusion upon it and which hath been but lately here experimentally discovered which is this—

Two needles of equal size being touched together at the same time with this stone and severally set on two tables with the Alphabet written circularly about them: two friends thus prepared and agreeing on the time may correspond at never so great a distance.

For by turning the needle in one Alphabet, the other in the distant table will by a secret sympathy turne itself after the like manner.

This secret was first experimented here by one Lamoran who being suspected of Apostacy because of his great intimacy with one Alchmerin his friend and a Jew, and his little adhesion to some of his opinions, was sent into the Island of Conversion a close prisoner; who there to hold constant intelligence with his intimate, first found out this admirable invention.

And therewith he shewed me those very two tables by which, during that his confinement, thus they communicated their thoughts each to the other.

THE APPLICATION OF THE ELECTRIC-MOTOR DRIVE TO MACHINE TOOLS.

W. ALLAN FIELD.

THE introduction of the electric motor has resulted in some truly remarkable modifications in the design and general appearance of the modern machine tool. Especially is this the case with medium and heavy tools, and a review of the production of leading machine tool manufacturers shows the tremendous popularity of the complete motor-driven tool.

With the advent of high-speed steels and the subsequent passing of the stepped speed cone, there opened a new field for the electric-motor drive; and the adaptability of the positive motor drive, with the consequent elimination of belt-slip, in order to permit the working of the tool to its fullest limits, was speedily recognised.

The most noticeable modification in up-to-date heavy duty tools is perhaps the omission of the cone pulley, which at one time was almost universal, and for which is substituted the all-gear drive. The omission of the cone pulley obviates the necessity of moving the belt from one step to another on the cone, and the mechanical method, that of throwing over a lever or hand-wheel in changing speeds, which is now generally adopted, proves a considerable saving in time and effort over the old method. The three principal means adopted for the main driving of the spindle or tool in electric motor-driven machine tools are as follow:—

(1) Where a constant-speed motor is used in conjunction with an all-gear head containing gears of varying diameters which

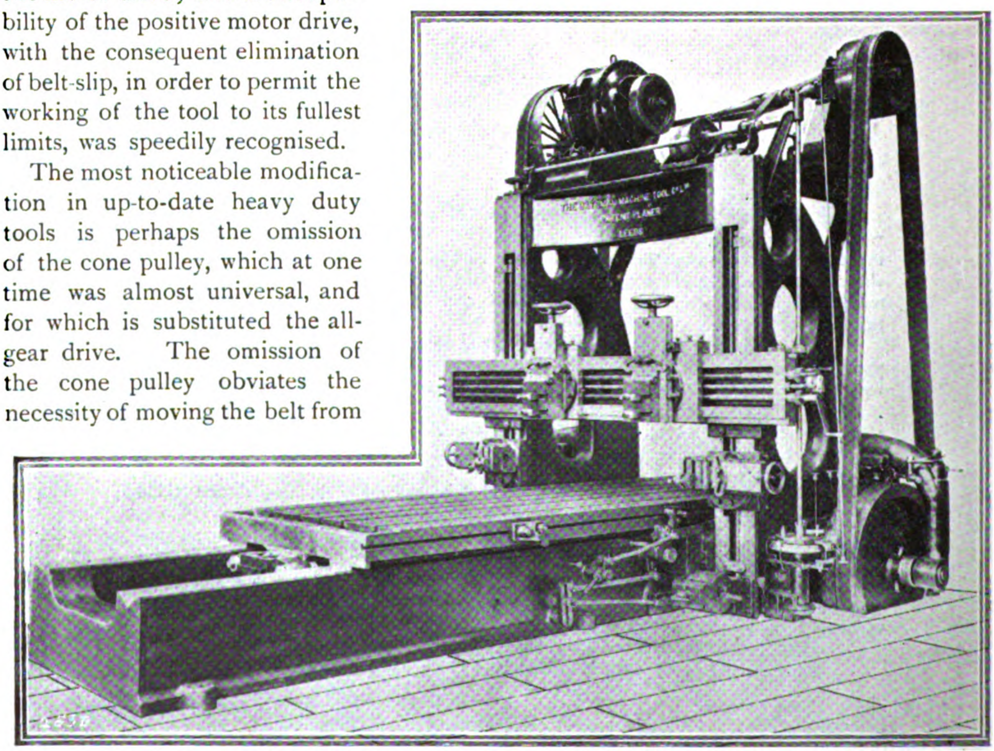


FIG. 1. THE BATEMAN PATENT HIGH-SPEED PLANER.

give the range of speeds suitable to the requirements of the machine and which are arranged in such a manner as to permit of changing the speeds by the throwing over of a clutch by means of a lever or hand-wheel. The levers are usually indexed so that the workman can see at a glance the resulting speed of any particular combination of gears; the mechanism is generally arranged to be interlocking, or fool-proof, to act as a safety device, and to prevent breakages which might arise through careless handling were it possible to throw in opposite-running combinations at one and the same time.

(2) Where a variable-speed motor is employed to give the finer ranges of speed, which were obtained from the speed cone, with the advantage that continuous variations are obtainable between fixed limits, instead of per saltum as with the cone pulley, whilst the coarser increases of speed are obtained by an all-gear arrangement as in case 1.

(3) Where the whole range of speed required is obtained from the motor itself. This method is very little used, probably because of the cost, and the space occupied by a motor with such wide limits of speed variation would render its use prohibitive. Nevertheless it is possible, with machine tool builders and electrical engineers working together on this problem, that in the near future we shall have a motor available with a suitable range of speeds and satisfying other requirements that will do away with the necessity of the geared arrangements which are at present such a noticeable and expensive feature in medium and heavy machine tools.

First and foremost of the problems which presented themselves to engineers of large plant in dealing with the application of the motor to machine tool driving was that of the group drive versus the individual drive. Undoubtedly the individual drive has the greater claim to superiority, but despite its advantages the first cost of installation renders its use prohibitive for small tools. It is, however, generally conceded that the individual motor is the better form of drive for portable and heavy duty tools, and most tools requiring, say, from 10h.p. upwards to drive are supplied with this form of drive. The advantages and economies accruing from the adoption of the individual drive are very considerable.

(1) A greater output is possible, due to the elimination of belt slip, and the working of the tool to its utmost limit.

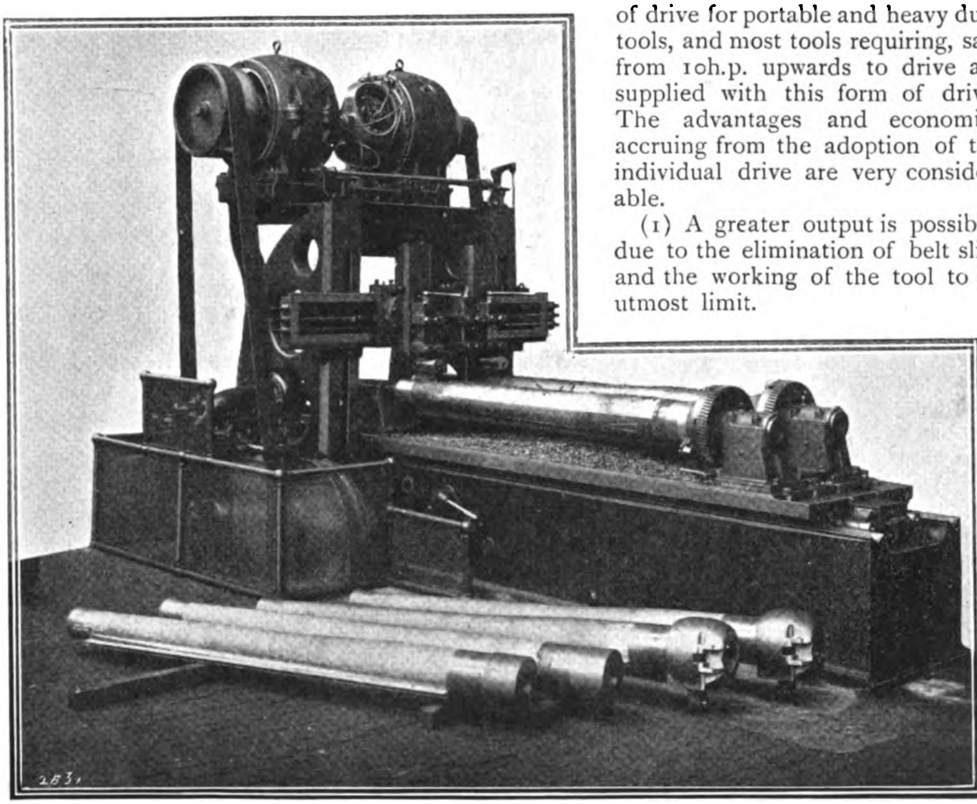


FIG. 2. THE BATEMAN PATENT VARIABLE HIGH-SPEED PLANER.

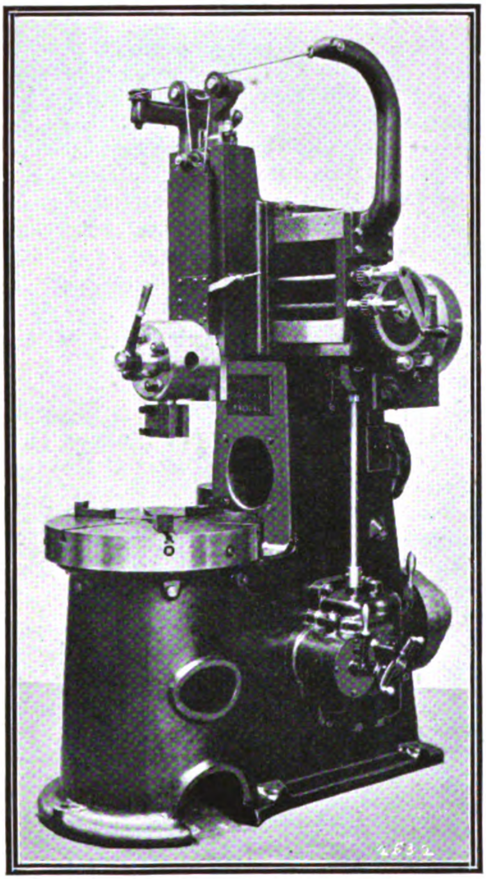


FIG. 3. THE STIRK ELECTRIC BORING AND TURNING MILL.

(2) Elimination of heavy belt drives and shafting and consequent saving in h.p. on friction load—in other words, minimum mechanical losses between motor and machine.

(3) Permits of independent operation of machines, as in overtime working.

(4) Provides an easy means of extension of plant, and machines can be readily placed wherever desired irrespective of line-shafting.

(5) Provides a simple means of testing the power required for various tools and cutters on different classes of work. In every up-to-date manufacturing establishment intelligently compiled records and tests are made with different steels and with different combinations of cutting tools. In manufacturing establishments where models of machine pieces are constantly changing, these tests and trials are a matter of every-day occurrence, and no foreman, manager, or superintendent can be confident of obtaining the greatest output and efficiency in working unless he is in a position to arrange for these tests, which are impossible with the old mechanical transmission, and which cannot be quite so conveniently conducted with the group drive without rendering idle the other machines on the line-shaft.

(6) More head-light and more space for overhead lifting arrangements, due to elimination of belting, line-shafting, and counters.

These as well as many other advantages are to be claimed for the individual drive, but unfortunately until the excessive first cost of this system is reduced by the introduction of cheaper motors, it is not likely to be universally adopted for driving gangs of small tools.

In drawing up a specification for the equipment of a manufacturing plant it is therefore advisable to arrange heavy and medium machines for the individual drive, and to divide each small tool department into convenient groups with mainshafts either belted to the motor or coupled directly to it.

The types of motors used in machine tool driving vary with different types of machines according to the nature of the load, and the motion of the cutting tool or table, as the case may be.

The standard tools may be classified as follows:

(*a*) Variable-speed machines with a heavy starting load, as with elevators, cranes, hoists, plate straightening rolls, &c.

(*b*) Variable-speed machines where, in general, maximum power is required on minimum speed.

Under this heading are to be included the following machines, lathes, boring and turning mills, milling machines, slotting and shaping machines, drilling machines, planing machines (with variable-speed drive).

There are two electric systems from which to choose the method of distribution—the alternating-current system and direct-current system. The former does not at present play a very prominent part in machine tool driving. Of the two types of motor available with this system the synchronous motor is not self-starting and cannot be said to answer the requirements, whilst the induction motor, although eminently satisfactory if designed and used as a constant-speed machine in conjunction with a mechanical speed-changing device, is seldom used for variable-speed machines.

The direct-current motor fulfils the requirements much better than the alternating-current machine, and is the most popular system at the present time. It offers three kinds of motor, viz.:

(1) Series-wound motors.
(2) Compound-wound motors.
(3) Shunt-wound motors.

The series-wound motor possesses a great starting torque, but is unsuited to machine tool driving, since it cannot be depended on to maintain a constant speed under varying load. It is most suitable for cranes, hoists, elevators, plate bending rolls, &c., and regulated by hand.

The compound-wound motor is suitable for slightly varying speeds and sudden overloads, possesses a great starting torque, but maintains a more constant speed under varying loads than the series-wound motor. This type of motor is particularly adaptable to the type of tool belonging to class (*b*), which have a reciprocating motion of table or tool, viz., planing machines, slotting machines, shaping machines. With these machines the load increases much above the normal at the point of reversal of the table due to the large moment of inertia offered by the rotating and moving parts, and an otherwise excessive inrush of current due to the increased torque required of the motor is held in check by the compound winding.

The shunt-wound motor maintains a practically constant speed under varying load within the limits of its capacity. This characteristic renders it eminently suitable for variable-speed work, and those machines belonging to class (*b*), which have a rotary motion of table or tool, viz., lathes, milling machines, boring and turning mills, drilling machines.

Speed Control.

The usual methods employed to vary the speed of shunt-wound motors are as follows:

1. By varying the pressure in the armature circuit through the medium of a rheostat, the resultant speed is approximately in proportion to the voltage employed. By this method the power drops in proportion to the speed reduction, and the motor loses one of its most valuable qualities, since the speed varies greatly under varying load. For these reasons this method is seldom used.

2. By varying the strength of the field magnetism, the speed of the motor is varied accordingly. With this method a constant speed is maintained under varying loads, and there is less drop in power than arises by the former method. It has, however, the following disadvantage: When the speed increases, the power demanded is in exact proportion to that increase, if the required torque remains constant; and with a weakened field, the motor is unable to develop the required torque. Thus, in order to obtain a constant horse-power throughout the whole range of variation of speed, the motor is built larger than is required for the same horse-power at the normal speed; and, in order to obtain a large range of variation by this method, a large motor is necessary, but it will be seen that this characteristic of decrease in power with increase of speed and *vice versâ* is particularly suitable to the

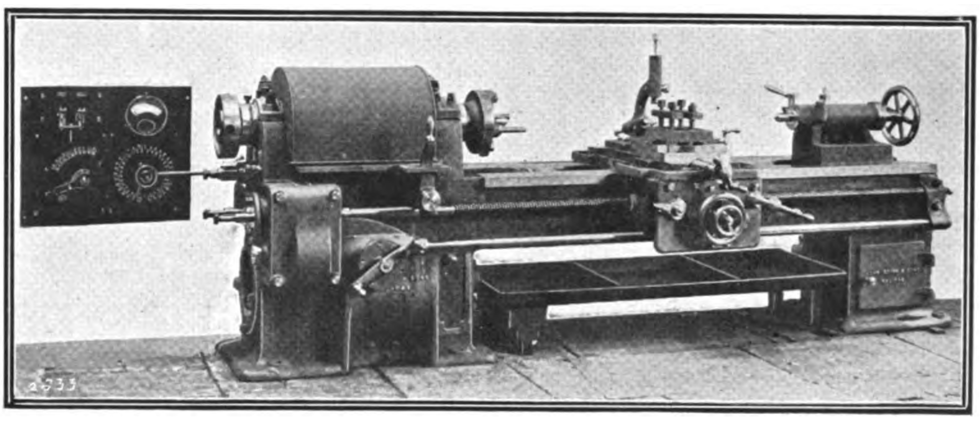


FIG. 4. THE STIRK ELECTRIC HIGH-SPEED LATHE.

requirements in driving lathes, boring mills, and milling machines.

Multiple Voltage System. — By varying the voltage at the armature terminals, and maintaining constant the field strength, the speed will vary according to the voltage. With a system of four wires, six voltages may be obtained, which give six fixed speeds in proportion to the voltages applied. Finer subdivisions may be obtained between these fixed speeds by the introduction of resistance into the armature circuit or by field control.

The Function of the Flywheel. — Flywheels are frequently introduced with beneficial results in driving tools which demand a large abnormal torque over short and frequent intervals.

The function of the flywheel is that of giving up a portion of its conserved energy at the moment of the abnormal demand for power in order to relieve the motor, and steady the drain on the mains. With the trifling fluctuations of speed permitted by the shunt motor when loaded above the normal, the flywheel is of no practical value; for a flywheel designed to suit the requirements with such slight variations of speed, would assume such large proportions as to render its use objectionable.

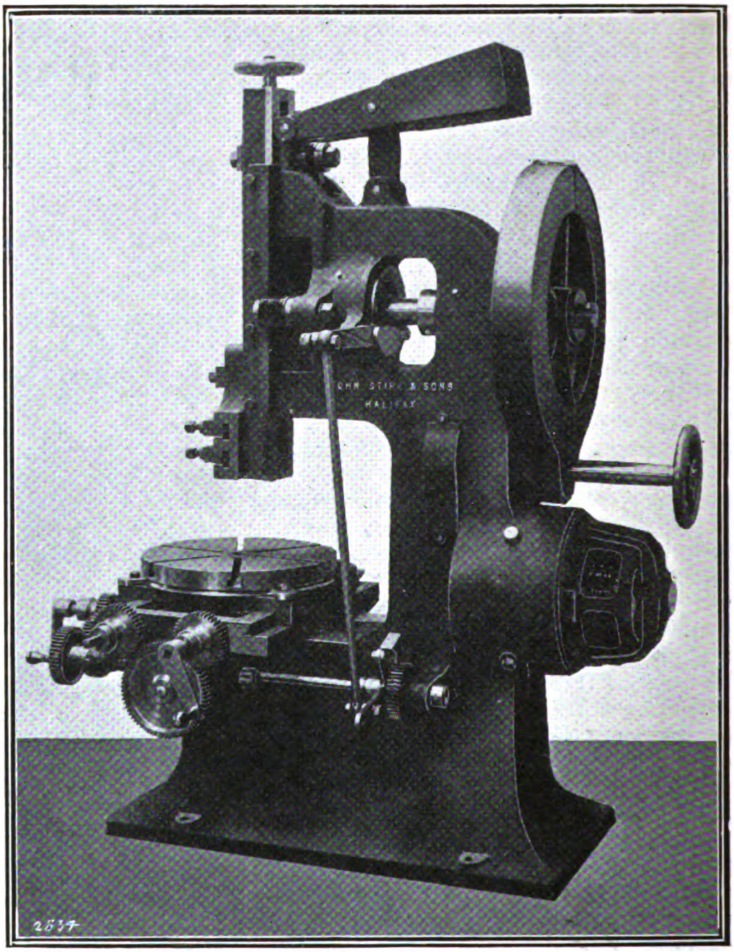


Fig. 5. The Stirk Electric Slotting Machine.

The larger variations of speed obtained when the compound-wound motor is subject to intermittent overloads renders this type of motor most suitable for the flywheel, and they are often applied either to the machine to be driven or fitted to the armature shaft itself.

Examples of the application of the flywheel are as follows:—Punching and shearing machines, slotting machines, shaping machines, planing machines.

Power Required for Machine Tools.

To the uninitiated there appears to be considerable divergence of opinion as regards the power to drive machine tools recommended by different makers. Machine tool engineers in designing standard machines compute the power required according to number of pounds of metal removed per minute. An average figure is taken according to the material operated on, and a maximum depth of cut and width of feed is fixed upon and arranged in proportion to the size of each particular line of machines. It need scarcely be mentioned that many special and abnormal machines are placed on the

market, and in such cases the power required for them should be computed each one on the basis of service required, and on its own merits. Therefore in making preliminary estimates as to the power required for a given plant, due consideration should be given to the conditions of working and the type of machine to be used. The following formulæ compiled by the Westinghouse Company can be applied when ordinary water-hardened steels are used, with an average speed of 20ft. per minute of cutting tool. In the event of high-speed steels being employed to the highest limit of their capacity it would be correct to increase the value given in proportion to the increased rate of cutting speed. It is however seldom that tools are kept constantly working up to their full capacity, this being especially the case with small standard tools. In estimating the total power required for any manufacturing establishment, this fact should be borne in mind and the Westinghouse formulæ will be found to suit the majority of cases.

Light Lathes with one cutting tool of ordinary water-hardened steel, at a cutting speed of 20ft. per minute.

$$\text{H.P.} = 0.15S - 1.$$

Heavy Lathes. — H.P. $= 0.234S - 2$. Where S = largest diameter admitted in inches.

Boring and Turning Mills.—For mills admitting 30in. diameter and over, using water-hardened steel at a cutting speed of 20ft. per minute.

H.P. $= 0.25S - 4$, where S = largest diameter admitted in inches.

Milling Machines.—For plano type milling machines with a peripheral speed of cutter of 20ft. per minute, using water-hardened steel.

H.P. $= 0.3W$ where W = distance between uprights in inches.

Drilling Machines.—For standard upright drills using water-hardened steel drills at a peripheral cutting speed of 20ft. per minute.

H.P. $= 0.06S$ where S = diameter of table in inches.

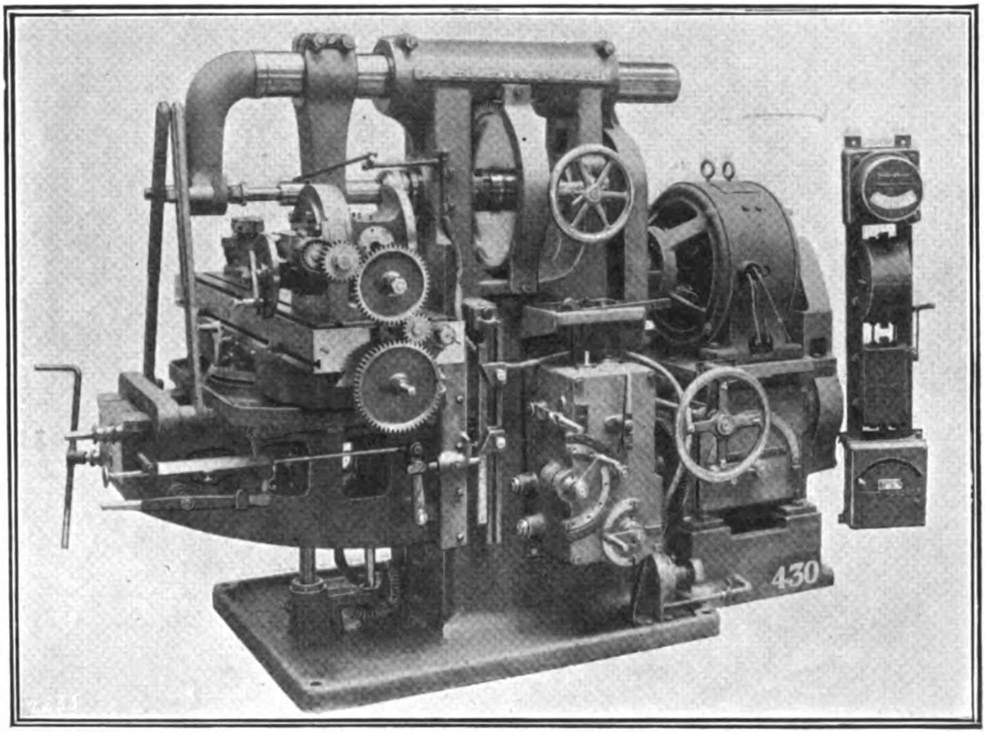


FIG. 6. HETHERINGTON HIGH-SPEED UNIVERSAL MILLING MACHINE.

Radial Drilling Machines.—Horse-power $= 0.1S$ where $S =$ length of radial arm in inches.

Slotting Machines.—For standard slotters using water-hardened steels at a cutting speed of 20ft. per minute.

Length of stroke in inches.	Horse-power.
5	4
10	5.5
15	6.5
20	7.5
25	8.75
30	10.00

Shaping Machines.—For shapers using water-hardened steel at a cutting speed of 20ft. per minute.

Length of stroke in inches.	Horse-power.
10	1.5
15	2.8
20	4.0
25	5.4
30	6.75

Planing Machines.—For standard planers using two cutting tools of water-hardened steel, with a speed ratio of cut to return of 1 : 3, and cutting speed of 20ft. per minute.

Light machines, H.P. $= 3W$.

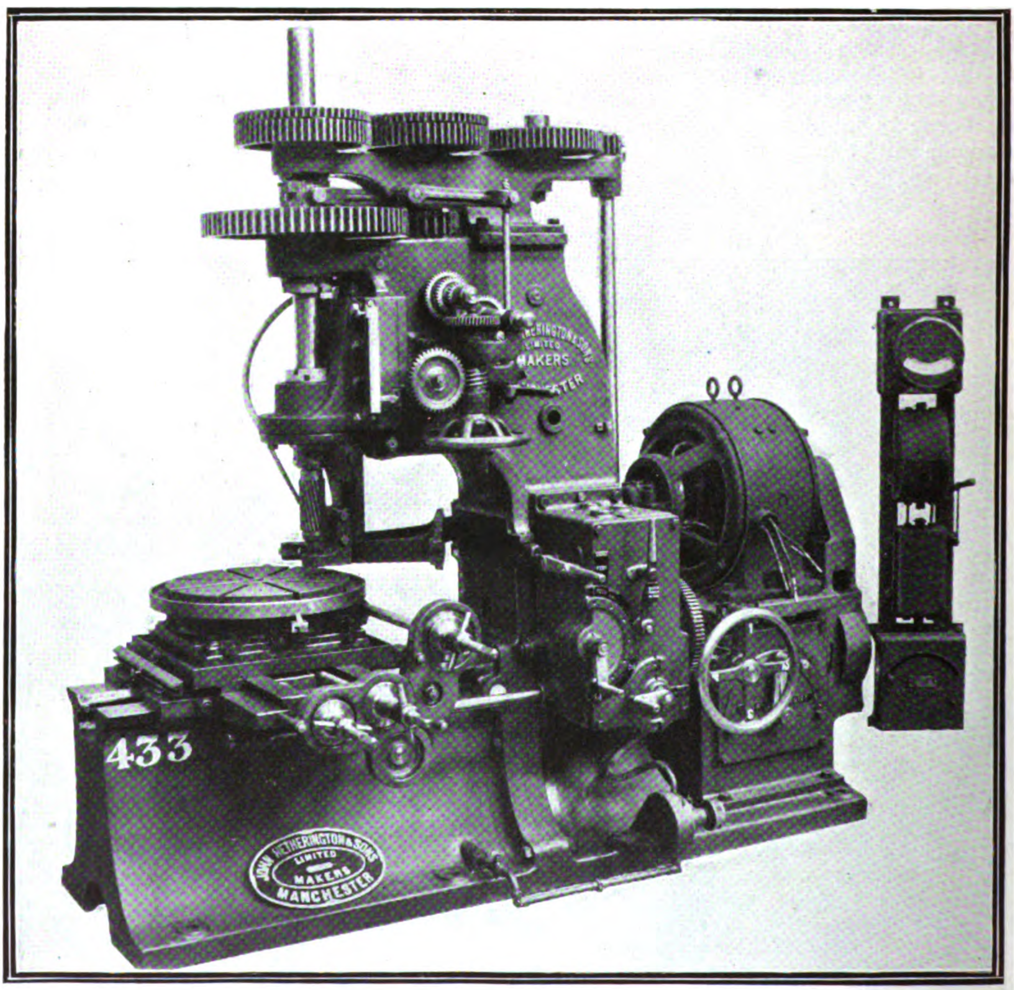


FIG. 7. HETHERINGTON HIGH-SPEED VERTICAL MILLING MACHINE.

Heavy machines, h.p. = $4.92 W$, where W = width admitted between standards in feet.

When abnormally heavy-duty, high-speed machines are under consideration, the power required should be investigated according to the nature of the stipulated requirements.

From a series of special dynamometer tests conducted by Dr. Nicholson at the Manchester School of Technology on Whitworth fluid compressed steel and medium hard cast iron with single point tools the vertical cutting pressures to remove one square inch of material were found to average 96 tons and 57 tons respectively. The traversing pressure for medium steel, *i.e.*, the side pressure required to hold the tool up to the work, was found to diminish 21 per cent. to 15 per cent. of the vertical cutting pressure, as the area of cut increased from 0.005 to 0.06 square inches with angle of tool 70deg., or from 22 tons to 14 tons per square inch. The surfacing pressure, *i.e.*, the endwise pressure holding the tool in toward the work, was found to decrease from 55 tons to 27 tons as the cut decreased from 0.005 to 0.06 square inches.

For medium cast iron the traversing pressure diminished from 28 per cent. to 12 per cent. of the vertical pressure as the cut diminished from 0.005 to 0.06 square inches, whilst the surfacing pressure varied from 58 per cent. to 31 per cent. of the vertical pressure required, with a tool angle of 80deg. in both cases.

In his book on "Lathe Design" Dr. Nicholson takes 115 tons per square inch as on the safe side for purposes of design. This figure includes the item of work done against the force of friction in pushing the shaving across the face of the tool and the frictional losses between motor and tool.

This figure is calculated to cover all workshop contingencies, and it would be right to assume it as covering the requirements for hard steel.

Taking this value the power required per cubic inch of material removed per minute would be :

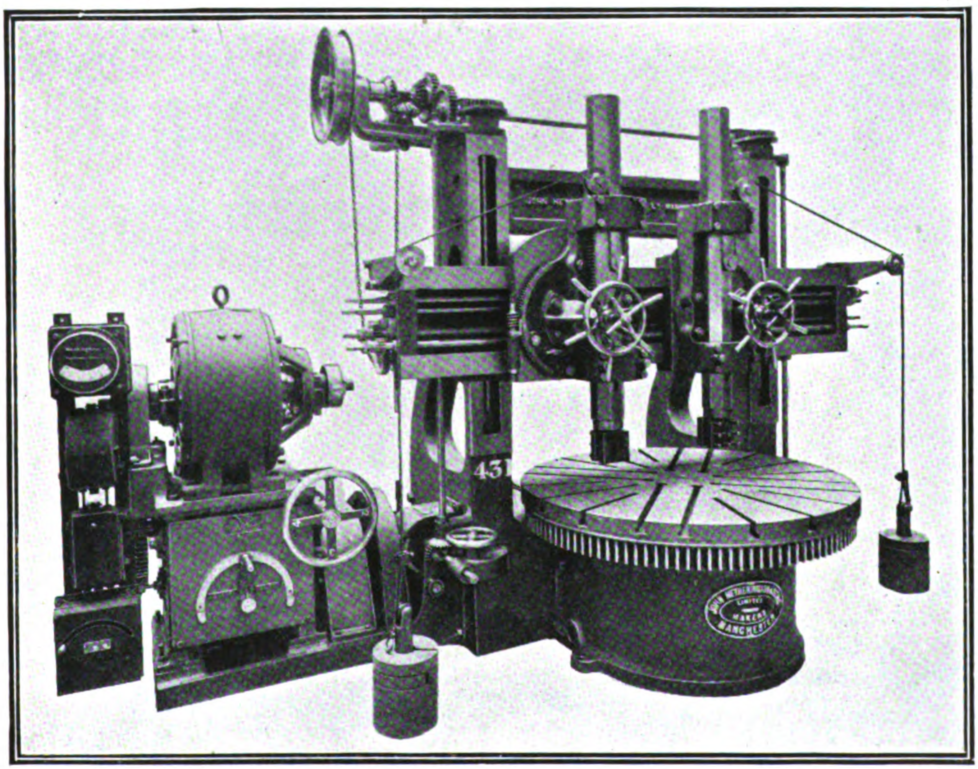


FIG. 8. HETHERINGTON HIGH-SPEED BORING AND TURNING MILL.

$$\frac{115 \times 2240}{33{,}000 \times 12} = 0.65\text{h.p.}$$

or taking weight of steel at 3.52 cubic inches per lb., the power required per lb. of metal removed per minute would be: $0.65 \times 3.52 = 2.35$, or, say, 2.5h.p. From this as a basis to work upon, the values for different materials operated upon are as follows :—

Horse-power required per lb. of metal removed per minute :

Medium steel and wrought iron	2.25h.p.
Hard steel	2.5 h.p.
Medium cast iron	1.3 h.p.
Hard cast iron...	1.75h.p.

Thus the formula for extra heavy duty becomes :

H.P. = $S \times N \times F \times D \times$ cutting speed in feet per minute $\times 12 \times W$, where

S = the value given in the table above.
N = number of tools employed.
F = feed in inches.
D = depth of cut in inches.
W = the weight in lb. per cubic inch of material operated upon.

The weight in lb. per cubic inch of various metals is as follows :—

Cast iron	0.258
Wrought iron	0.278
Steel	0.284

The above formula follows closely usual drawing-office practice in machines of this class, and although compiled from the results of Dr. Nicholson's experiments, which were made only with heavy lathes, it is reasonable to assume that it will hold good in calculations pertaining to all single-point cutting tools, viz., planers, slotters, boring mills, shaping machines.

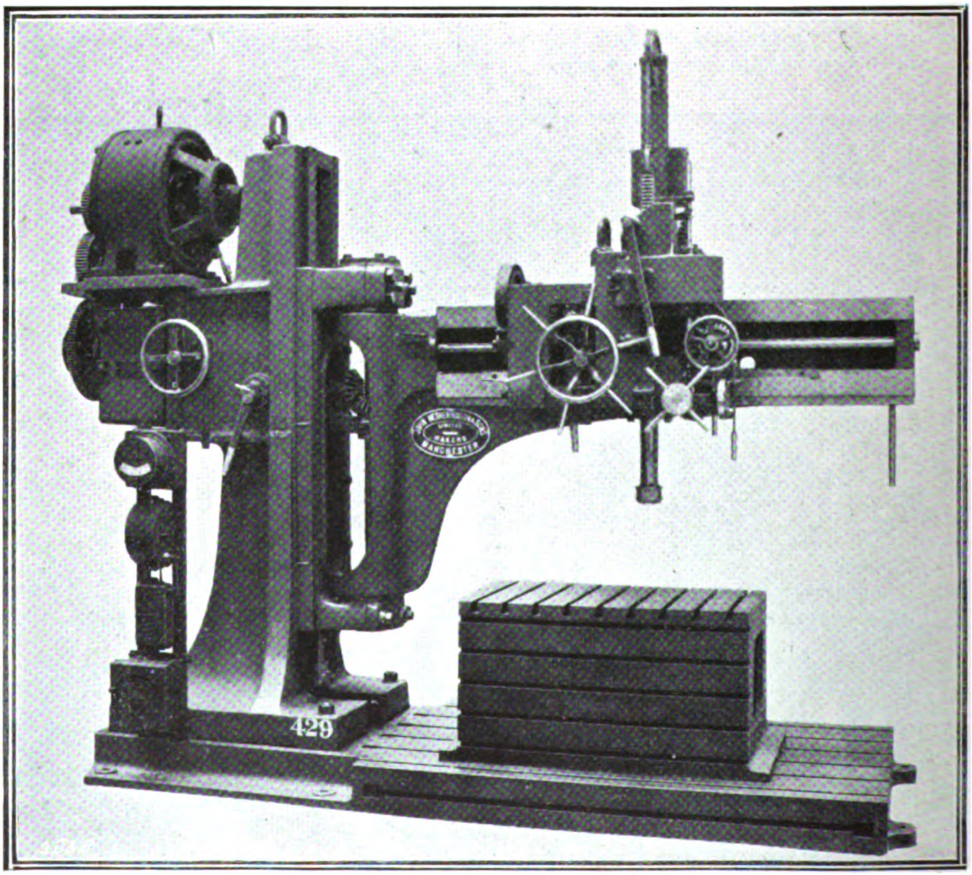


FIG. 9. HETHERINGTON HIGH-SPEED RADIAL DRILL.

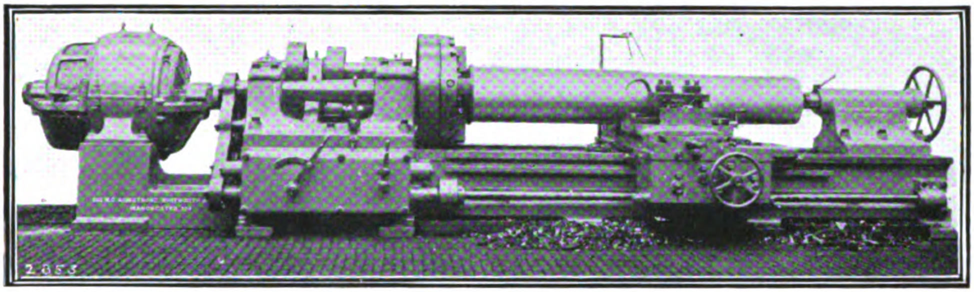


FIG. 10. ARMSTRONG-WHITWORTH HIGH-SPEED LATHE.

The milling machine is notably less efficient, as far as concerns power absorbed, than are machines using single-point tools; this is no doubt partly due to the fact that in milling, several teeth of the cutter are simultaneously in operation. Experiments go to show that about seven times the power required to remove a given amount of metal in a lathe or planing machine is required for a milling machine. The values given in the above table would have to be multiplied by seven for calculations respecting milling machines, and the table of powers would be:

Horse-power required for milling machines per lb. of metal removed per minute:

Medium steel and wrought iron	15.75h.p.
Hard steel	17.5 h.p.
Medium cast iron	9.1 h.p.
Hard cast iron	12.25h.p.

A few examples of the numerous complete motor-driven tools which are at present on the market will now be considered. Fig. 1 shows a general view of the "Bateman" patent high-speed planer. The machine admits 6ft. × 6ft., and will plane pieces up

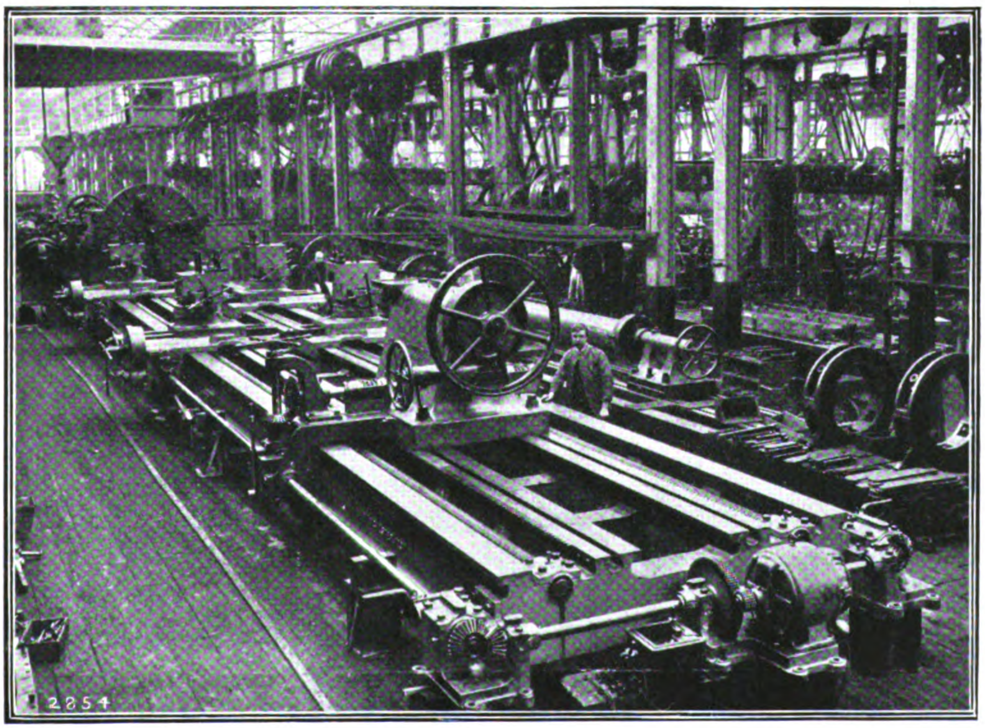


FIG. 11. 48IN. ARMSTRONG-WHITWORTH GUN LATHE.

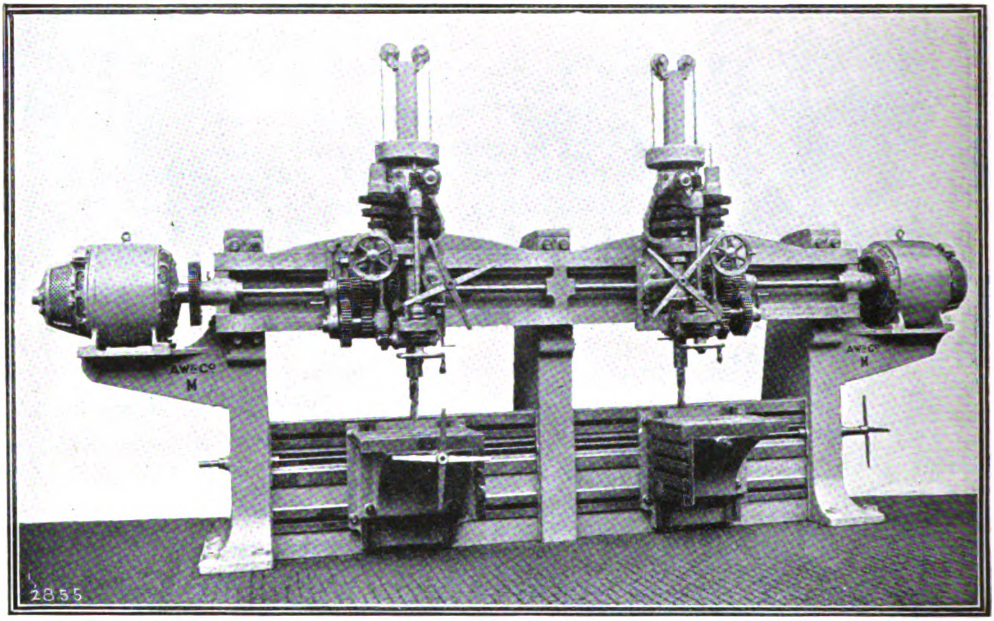


Fig. 12. Armstrong-Whitworth Duplex Drilling Machine.

to 14ft. long. A motor of 35h.p. is geared with a rawhide pinion to the overhead countershaft, and is fitted with a flywheel on the armature shaft. The planers manufactured by this firm are also fitted with their patent flywheel loose pulleys. A friction clutch operates between the flywheel (*i.e.*, the loose pulley) and the fast pulley, so that a portion of the conserved energy of the flywheel is effectively used in securing prompt reversals, with precision of table travel. Prompt reversals and rapid accelerations to full speed at the instant of reversal are of vital importance in planing machines, since the productive capacity of a planer depends on the cycle time, *i.e.*, time of 1 cut + time of 1 return.

In some machines the time lost in overcoming the inertia of rotating parts is very considerable, and the earning capacity of the "Bateman" planer is undoubtedly considerably increased by the application of the patent flywheel device. Another noteworthy feature of these machines, is the patent sliding

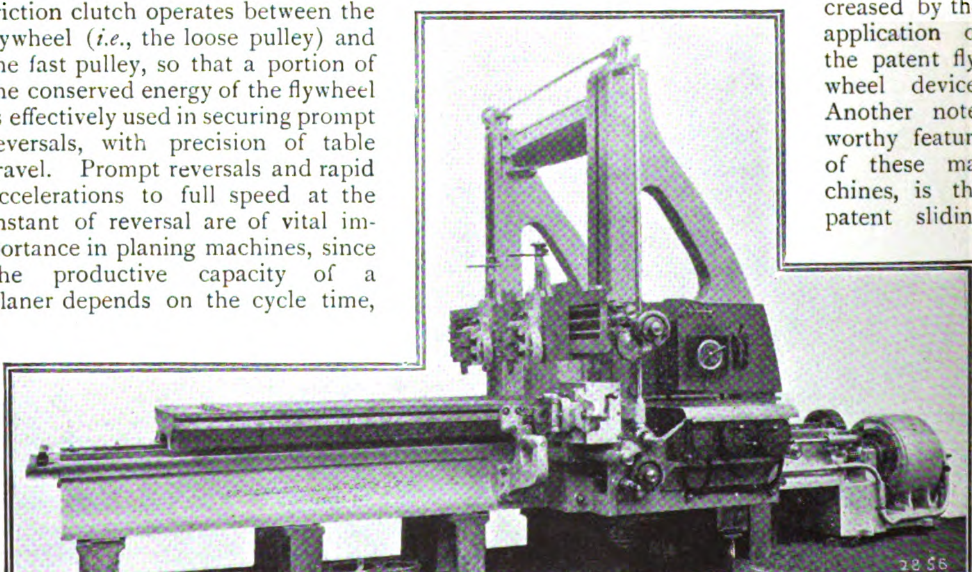


Fig. 13. Armstrong-Whitworth Electric Planing Machine.

rack fixed in a planed groove on the under side of the table, and poised between adjustable springs with the object of minimising the shock at reversal, which is due to the sudden impact of the toothed gearing with the change of direction of rotation.

The machine illustrated in Fig. 1 is made to return at 120ft. per minute, with a cutting speed of 45ft. per minute, and is capable of taking four cuts simultaneously in hard steel rails, depth of cut being $1\frac{3}{8}$in., with a feed of $\frac{1}{30}$in.

The firm also manufacture planers with variable cutting speeds and constant return. In most cases the changes are obtained with constant-speed motors used in conjunction with a change-speed gear box; but they frequently supply planers driven by two separate motors, one of which, a variable-speed machine, controls the cut, whilst a constant-speed motor controls the return.

Fig. 2 shows a machine of this type, with variable cutting speeds 20ft. to 60ft. per minute. The variable-speed motor is of 15h.p., and runs at 600r.p.m.

Fig. 3 shows a 30in. boring and turning mill manufactured by Messrs. John Stirk & Sons, Halifax. The machine is fitted with the firm's patent electric drive; the $2\frac{1}{2}$h.p. motor is built into the main framing, with pole pieces fixed inside the standard.

The motor is arranged for shunt-field regulation, and has a range of speeds from 800r.p.m. to 1600r.p.m., through the medium of a rheostat of the Sturtevant type. The belt cones and gearing are so arranged that any speed of table can be obtained between 5r.p.m. and 250r.p.m.

The quick speeds are particularly intended for boring, and a uniform cutting speed of 40ft. per minute is obtained on any diameter from $3\frac{1}{2}$in. to 28in. with the double gear in operation.

Fig. 4 shows the 8in. Stirk lathe fitted with a $7\frac{1}{2}$h.p. variable-speed motor running at any speed between 400 and 1200r.p.m. The motor is built in the bed casting and is geared to the lathe spindle, through the medium of a chain drive. The cutting speeds are 40ft., 60ft., 80ft., and 120ft. per minute, and when any one of these speeds has been decided upon it can be maintained on any diameter beween $2\frac{1}{2}$in. and $7\frac{1}{2}$in.

The 6in. slotting machine illustrated by Fig. 5 is also fitted with Messrs. Stirk's patent self-contained motor drive, which no doubt constitutes the neatest and most compact form of drive possible for machine tools. In this case a variable-speed motor running between 500 and 1500r.p.m. is geared by chain to the pinion shaft on to the usual gearing at the rear of the machine. The speed regulator is marked so as to enable the workman to determine at a glance the speed most suitable for the material to be operated upon.

A fine specimen of the motor-driven tool is exemplified by the high-speed universal milling machine manufactured by Messrs. John Hetherington & Sons, Ltd., of Manchester, and illustrated in Fig. 6. The firm have adopted a standard type of gear box which is applied to lathes, drilling machines, slotting machines, and milling machines. In this example the spindle speeds are sixteen in number and are arranged in geometrical progression. A hand wheel and combination gives eight changes, which are further increased to sixteen by a two-speed back gear

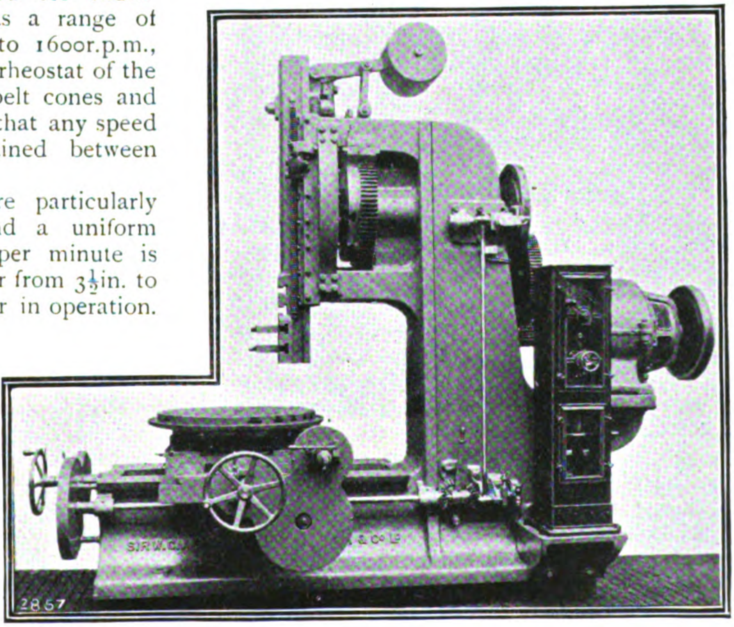


FIG. 14. ARMSTRONG-WHITWORTH ELECTRIC SLOTTING MACHINE.

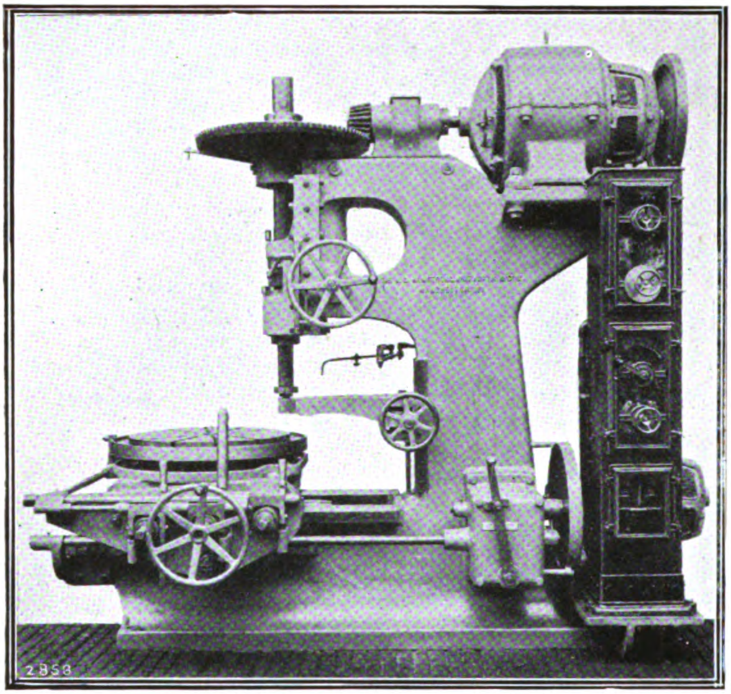


FIG. 15. ARMSTRONG-WHITWORTH ELECTRIC VERTICAL MILLING MACHINE.

on the cutter spindle itself. The reversible self-acting positive feeds are provided with an automatic trip motion and range from $\frac{1}{4}$in. to 6in. per minute, being eight in number for each spindle feed. The machine is of very rigid construction, with an overhanging arm $5\frac{1}{2}$in. in diameter, and will admit 1ft. 9in. diameter and an arbor 2ft. long. The vertical longitudinal and transverse slides have screws fitted with indexed discs reading to thousandths of an inch for fine adjustments, and are also fitted with indexed steel rules which permit of approximate settings, and obviate the necessity of counting the revolutions of the screws in making long adjustments for repetition work. A quick power adjustment is provided for the knee bracket and table, whilst a slow-speed rotary pump fixed to the base of the machine provides for lubrication of the cutters. The 12h.p. motor and switch gear are supplied by the Westinghouse Company.

Fig. 7 represents Messrs. Hetherington's high-speed vertical milling and drilling machine with profiling attachment. The main drive is by a 12h.p. constant-speed Westinghouse motor used in conjunction with the standard gear box, and sixteen changes of speed are obtained by means of indexed hand wheel and lever. A self-acting drilling feed is provided with three changes for each of the sixteen spindle speeds. The table movements are provided with eight feeds and range from $\frac{1}{4}$in. to 6in. per minute. The switch gear, which is also supplied by the Westinghouse Company, is suitable for direct-current circuits up to 600 volts. All live parts are enclosed in cast-iron boxes, and a safety interlocking arrangement is introduced between switches and fuses, so that the circuit is broken at the switch before the fuse can be removed.

A 5ft. boring and turning mill is shown in Fig. 8. The machine is driven by an 18h.p. motor through a gear box underneath, giving a range of twenty-four table speeds in double, treble, and quadruple gearing. A power adjustment to the cross-slide is provided driven from a belt pulley on the motor shaft, and reversed by means of a clutch. The table feeds are eight in number for each of the table speeds, and range from $\frac{1}{32}$in. to $\frac{3}{8}$in. per revolution of the table.

Another fine example of the motor-driven tool is Messrs. Hetherington's 7ft. radial drilling and tapping machine, which is shown in Fig. 9. The machine is driven by a 14h.p. constant-speed Westinghouse motor, has a 3in. spindle with a range of eight speeds from 21r.p.m. to 406r.p.m., four of which are obtained through the gear box, these being doubled through the medium of a two-speed change device on the saddle. The radial arm is elevated and lowered by power under control of the lever shown on the side of the standard. The spindle feeds per revolution of the spindle are four in number and controlled by means of the indexed lever on the saddle. The correct feed may be determined by the operator at a glance according to the size of drill

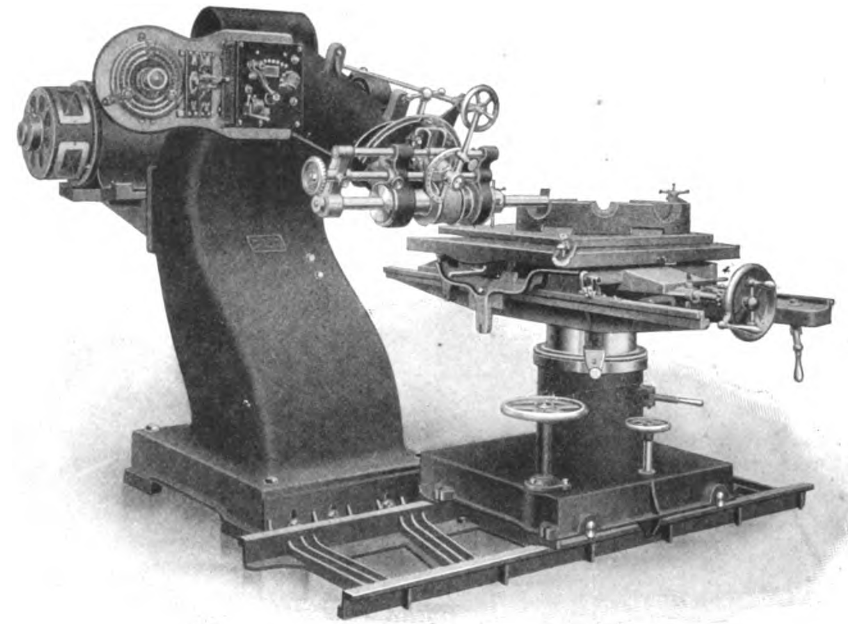


FIG. 16. THE WADKIN ELECTRIC WOOD-WORKING MACHINE.

and material operated upon. The machine will bore up to 12in. diameter and drill to a depth of 18in.

Messrs. W. G. Armstrong Whitworth, of Manchester, have adopted the electric drive for machine tools throughout their workshops, and are realising to the fullest extent the economies and advantages, with greater output, to be obtained by this method in conjunction with the use of high-speed steel. Line-shafts, driving groups of small tools, are belted or geared to motors, whilst most of the heavy tools, of which the firm use a great number, owing to the nature of the work engaged upon, are fitted with the individual drive. Machines requiring 5h.p. and over are arranged for the separate motor drive, and motors of an output up to 60h.p. have been applied to individual machines.

Fig. 10 consists of an 18in. lathe, which was built to demonstrate the use of high-speed steels, and was exhibited at the Liège Exhibition of Engineering and Machinery in 1906. The lathe is driven by a 60h.p. motor, with a variable-speed regulation of 3 to 1. Through the all-gear head the lathe has a large range of cutting speeds, and has feeds ranging from $\frac{1}{16}$in. to $\frac{1}{4}$in. The lathe will take a cut in medium hard steel $1\frac{1}{2}$in. deep by $\frac{1}{4}$in. at a cutting speed of 30ft. per minute.

The arrangement of driving for a 48in. gun lathe is shown in Fig. 11. A 50h.p. variable-speed motor constitutes the main drive; whilst the 10h.p. constant-speed motor at the right-hand end of the bed controls the quick-placing mechanism for the saddles and loose headstock.

The illustrations Figs. 12, 13, 14, and 15 show electrically-driven tools manufactured and used by Messrs. Armstrong Whitworth. Fig. 12, a powerful duplex drilling machine, is driven by two 16h.p. variable-speed motors, one at each end of the cross-slide. The changes of speed obtainable from the motor are further increased by a nest of change gearing on each saddle; whilst three changes of feed are available for each of the spindle speeds. The driving arrangement and control of motor for a 6ft. × 6ft. × 16ft. planer in Fig. 13 is clearly shown by the illustration. The variable-speed motor reverses at each end of the stroke of the table. A switch regulating the cutting speeds of the table is conveniently placed for the workmen on the right-hand upright. Three switches shown on the base of the upright control the reversing arrangement, which are tripped automatically by the tappets on the table.

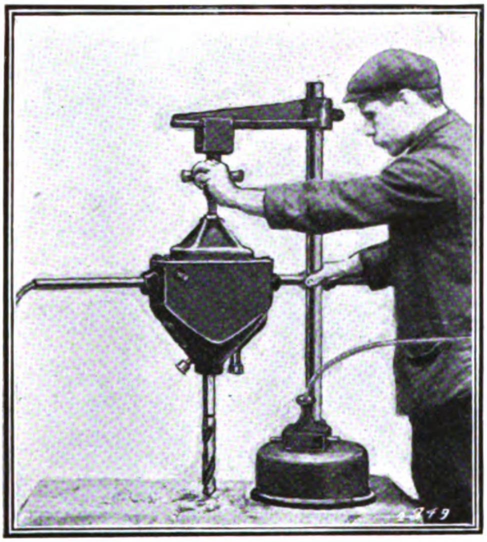


FIG. 17. KRAMOS ELECTRIC DRILL.

In wood-working shops, electrical driving proves a great saving in transmission losses, owing to the intermittent character of the work, and with this class of machinery the perfect flexibility of the electric system, as to location of machines, is particularly convenient, whilst awkward belt drives, owing to the scattered arrangement of machines, may be entirely eliminated. An example of the electrically driven wood-working machine is given in Fig. 16, the "Universal" mechanical wood-worker manufactured by Messrs. Wadkin & Co., of Leicester. The machine is built to deal with a very wide range of plain and intricate work in wood-working and pattern-making. The machine is essentially a producer, and provides a simple and mechanical means of dealing with a great variety of work which would otherwise need to be performed by hand at the expense of much time and labour. The machine consists of a main frame carrying a

Fig. 14 illustrates a 12in. stroke slotting machine, driven by a variable-speed motor placed on the standard behind the machine. The pillar-type switch box is carried on a bracket fixed to the base of the machine, and is fitted with double-pole switch, starting and regulating switches, with overload and no-volt release.

In the example given in Fig. 15, a vertical milling machine, a variable-speed motor drives the cutter spindle, whilst quick-placing movements and feeds for the table slides are obtained by means of a smaller motor fixed on the base of the upright. The primary object of this arrangement is to render the feed motions independent of the spindle speeds. Under these conditions the correct feed required, according to the work being dealt with, is more readily obtained. Where table feeds are driven from the spindle mechanism, it frequently happens that when using high spindle speed (*i.e.*, when using small diameters of cutters) the resultant feed per minute is more than the machine will stand; or, on the other hand, with slow speeds in use for large cutters, the resultant feed is but a fraction of what the machine is capable of taking with an independent feed arrangement. The pillar type panel is provided with starting and regulating switches, and circuit-breakers for each motor.

The electro-motor applied to machinery has a very wide field, and its application to wood-working machinery has proved as satisfactory as to metal-cutting machinery.

FIG. 18. KRAMOS ELECTRIC DRILL WITH MAGNETIC PILLAR.

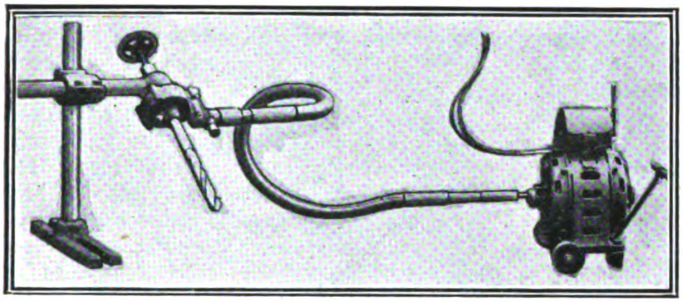


FIG. 19. KRAMOS ELECTRICALLY DRIVEN DRILL PRESS.

cutter spindle and work table with universal movements for circular work, internal and external radius work, and all kinds of irregular shapes. A universal spiral and dividing head is also manufactured by the firm for dealing with gear patterns, spiral and twist work, &c.

The machine is driven by a 5h.p. variable-speed motor fixed on a bracket at the rear of the machine and belted to the cutter spindle. The starting, reversing, and speed-controlling switches are placed in a convenient position on the main frame.

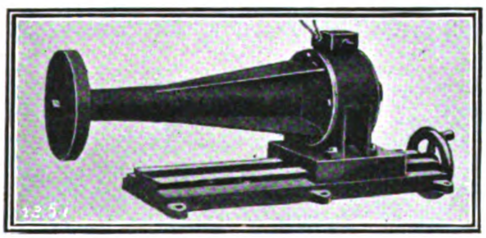


FIG. 20. KRAMOS ELECTRIC GRINDER.

Portable Electric Tools.

The advantages and economies due to the perfect flexibility and increased outputs of the electric power system are so marked in this class of tool as to render their use indispensable on some classes of work. Broadly speaking, portable tools may be divided into two classes:

1. Heavy portable machines.
2. Light portable machines.

Heavy portable machines are used principally in workshops engaged on large engine work, and those engaged in the manufacture of the heavier types of electrical machinery. Both classes of portable tools are used on work similar to that mentioned above; but the lighter types are used more extensively by shipbuilders, boiler-makers, iron and steel constructional works, locomotive builders, collieries, and tool-makers.

Machines coming under Class 1 include heavy drilling and tapping machines, vertical and side planers, heavy rotary planers, and heavy milling machines, and are intended for operation on large machined castings which cannot be dealt with in the usual way by ordinary fixed machine tools. Heavy portable tools are used in conjunction with a system of floor-plates, concreted and levelled, and provided with "T" slots wherewith to fix the work and fasten down the particular portable machine to be applied.

Machines coming under Class 2 include drilling machines of capacity, say, up to 3in. diameter, hand-drills with breast or mechanical feed, lifting magnets, hoisting tackle, and grinding attachments, and are principally used by those engaged on iron and steel structures of large bulk, and when operating in awkward or confined positions. A few examples of the many types of light portable electric tools will now be considered. The portable electric drill has now entirely superseded the hand ratchet brace, and although pneumatic tools are an improvement over the hand methods, the cost of installing special air-compressors and the inefficiency of pneumatic appliances are serious disadvantages. Electric tools have all the advantages of pneumatic tools without their disadvantages. They are more powerful, more reliable, more efficient, and can be supplied from any electric light main without necessitating the installation of any special plant.

Fig. 17 shows an electric drill of the self-contained type manufactured by Messrs. Kramos, of Bath. The framing, an aluminium casting, totally encloses all working parts. It is flat in shape, which is an advan-

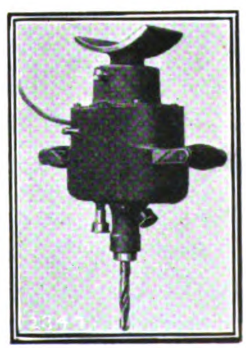


FIG. 21. KRAMOS ELECTRIC HAND DRILL.

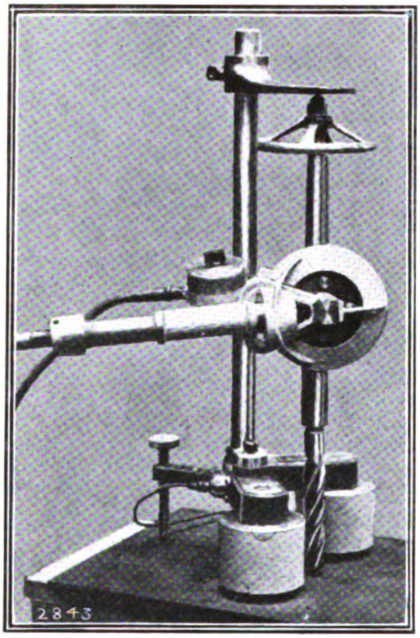


Fig. 22. C. and I. Electro-magnetic Drill Stand.

tage when working in confined positions. The motor is of the two-pole type and series wound, thus enabling the operator to vary the speed of the drill by varying the pressure on the feed-screw. No mechanical means are employed to obtain the speed variation. The brush gear is of special design to ensure radial feed of carbons under all working conditions, and a switch of the push type is contained inside the drill casing. The drill is supplied with 15ft. of armoured cable, and is so arranged that either breast-plate or feed-screw can be fitted as desired.

The firm manufacture this machine in three sizes, their capacities being $\frac{3}{4}$in. diameter, 1in. diameter, and $1\frac{1}{2}$in. diameter respectively. For heavier duty, equipments consisting of a motor flexible shaft with universal joint connections and drill press are supplied (see Fig. 19). The machine illustrated in Fig. 17 is shown used in connection with the firm's magnetic drill stand, which does away with the necessity of clamping an ordinary pillar to the work. The magnet consists of an outer casing of high permeability magnet steel with a central core completely enclosing a coil consisting of layers of double-cotton-covered copper wire, insulating from each other and from the casing. The magnet is excited by a switch of the push type placed on the outside of the casing in a cast-iron box. Fig. 18 is given to demonstrate the ample gripping power of the magnetic drill stand. Fig. 20 shows the Kramos self-contained electric grinder, which can be used for internal and external grinding, grinding commutators on large machines in central stations, &c., or it can be fixed to the slide rest of a lathe and used as a grinding attachment for cylindrical work. The motor is $\frac{1}{3}$h.p., running at 2000r.p.m., and carries a wheel 6in. diameter. The machine has a traverse of 2ft. by hand wheel. The Kramos electric hand drill with breast feed is shown in Fig. 21. These tools can be coupled to ordinary lamp-holders. The simplicity with which tools of

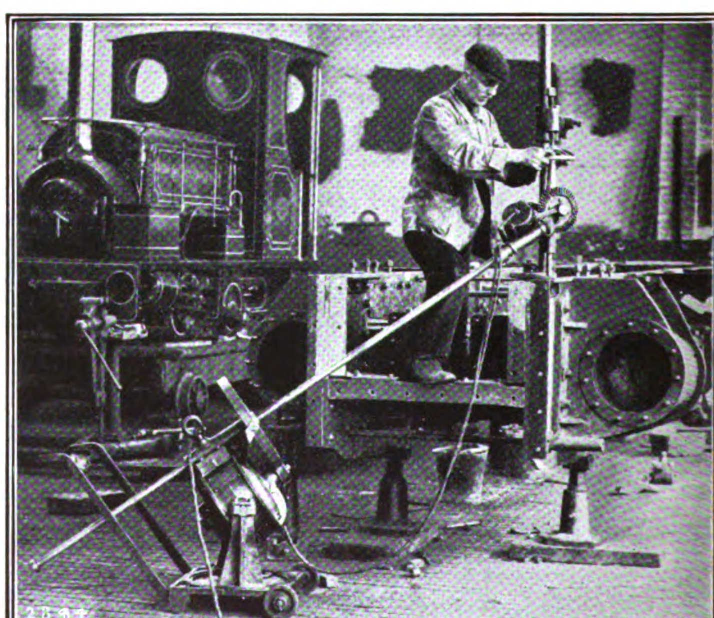


Fig. 23. C. and I. Electric Drill in Use.

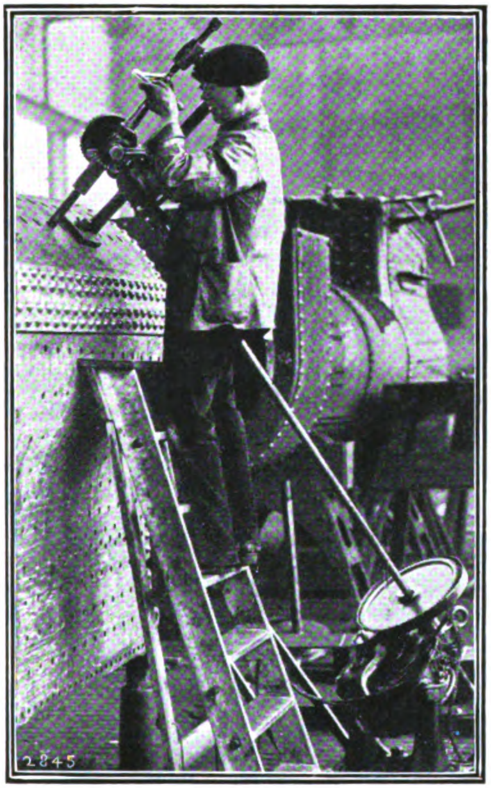


FIG. 24. THE C. AND I. PORTABLE ELECTRIC DRILL.

this class are applied renders them extremely useful on a very wide range of work.

Figs. 23 and 24 illustrate applications of the C. and I. portable electric drilling machine manufactured by Messrs. the United States Metallic Packing Company, Ltd., Bradford. The outfit comprises a motor, carriage, sliding shaft, and universal-movement drill head. The motor is mounted on horizontal trunnions, and carried in a frame which can be moved in a complete circle, the whole being mounted on a truck or carriage to permit of easy movement from place to place. If shape of work or position of working renders it necessary, the motor can be supported by a bow or stirrup and suspended by means of block and tackle from any convenient position. On the top of the motor is a bracket carrying a hollow shaft driven from the armature shaft by spur gearing. Through the hollow shaft slides a long splined shaft, one end of which is geared to the drill head with a universal movement. With this arrangement the apparatus can be worked in almost any position. The gearing on the drill head is entirely enclosed, and all terminals are protected. The series-wound motor can be made to suit any voltage from 50 volts to 500 volts on continuous-current circuits, or for single-phase, two-phase, and three-phase alternating current. A switch is conveniently fixed to the drill head itself so as to place the machine under the ready control of the workman. This machine is made in three sizes, 1in., 2in., and 3in. respectively. The firm also manufacture an electric hand drill which is arranged for both breast and ratchet feed.

Either type of machine may be used with the magnetic stand shown in Fig. 22. These stands have a tripod base, two legs of which are electro-magnets and the third an adjustable screw. The drill is set between the magnets, whilst the adjustable screw takes the thrust of the feed; with this arrangement the makers claim a maximum gripping effort with a minimum weight. The magnets are of special quality steel with magnet coils of high conductivity copper, carefully insulated and enclosed in water-tight brass cases.

A switch of the quick make and break type is provided for exciting the magnets, and 30ft. of flexible cable, together with plug adapter, to suit ordinary lamp-holders, is supplied with each stand.

The stand is made in three sizes, and their approximate weights are 40lb., 65lb., and 95lb. respectively.

THE USE OF ELECTRICITY IN THE TEXTILE INDUSTRY.

FRANK NASMITH.

SLOWLY but very surely electricity is coming to be recognised as a power of extreme value to the textile industry. Unfortunately there have been a considerable number of failures in connection with the application of electric power to spinning mills, which have had the effect of making the hard-headed conservative Lancashire mill manager refuse to have, or hear anything about, a power of which he knows little, and to stand by steam power as being the surest and most economical for his purposes. These failures have been due, in the writer's opinion, to only one reason—the ignorance of electrical engineers with regard to the necessities and conditions prevailing in the textile industries. Although many may not think so, the textile industries present problems as regards driving which are not to be found elsewhere. The many and varied machines employed, the very nature of the material being dealt with, and the keen competition which requires the machines to be kept at a high productive capacity necessitate a system of driving of almost unique characteristics.

In the earlier stages of the fight between steam and electricity—and we are prone to believe that it will for many years be a strenuous one—the electrical engineers in many

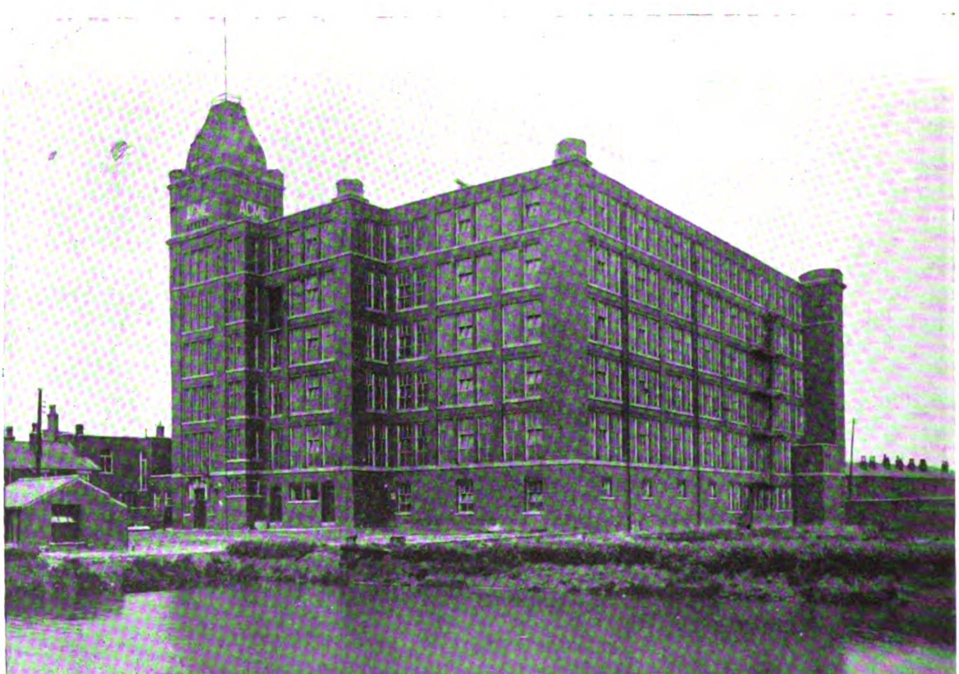


FIG. I. THE FIRST ENGLISH COTTON MILL WITH COMPLETE ELECTRICAL EQUIPMENT.

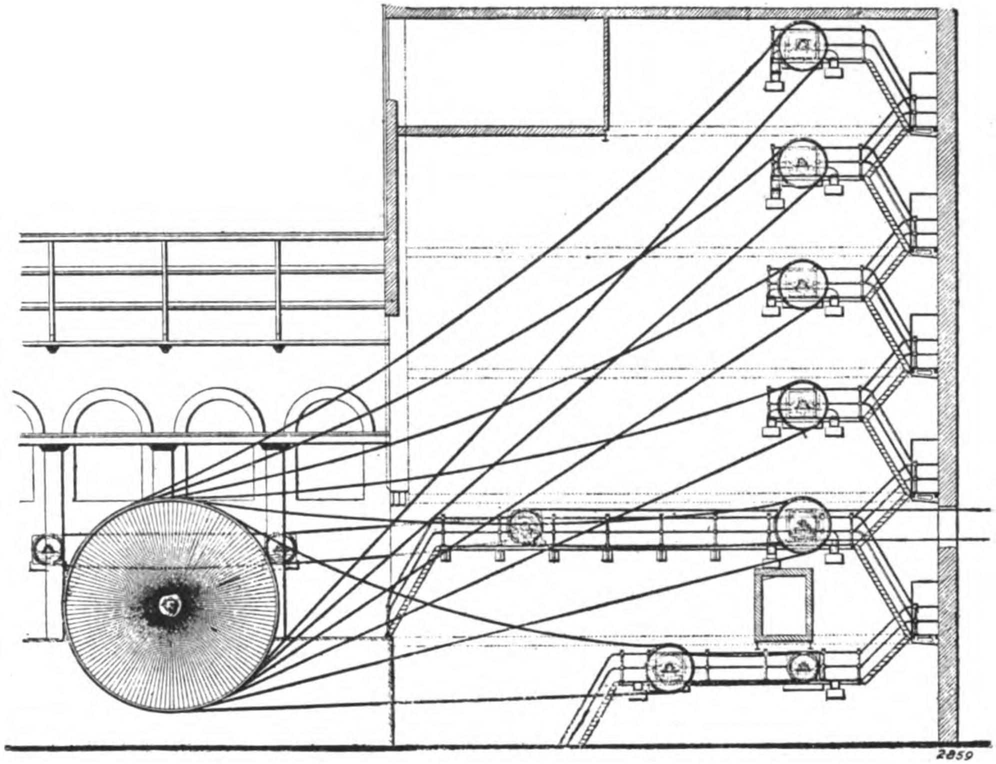


FIG. 2. MAIN ROPE DRIVING ARRANGEMENT OF COTTON MILL, AS SUPPLIED BY MESSRS. DAVID BRIDGE & CO.

cases took too much for granted. They applied methods which had been successful in other industries without making the particular modifications necessary to the textile industry, with the result that failure succeeded failure, and at the very outset, in this country at any rate, electricity as a motive power came to be deprecated by mill-owners. Electrical engineers have often been urged to treat the textile industry and the problems of driving presented therein as being quite apart and distinct from those of any other industry in which they have been interested. It is, however, gratifying to be able to record that during the past few years great efforts have been made by a number of electrical engineers to grasp and solve these problems thoroughly, and it is practically certain that in the near future electric power will take its proper place, which cannot be anything but the highest one, in relation to the textile industry.

It must not be forgotten that steam engineers have years of tradition to stand upon, and that those who cater for the cotton, woollen, silk and flax industries have brought their methods to a very high state of perfection. Another power which is being recognised, and which will certainly have to be considered in the near future, is gas. Already there are examples of successful installations working at a low cost and giving considerable satisfaction in which producer gas is employed in conjunction with a highly-improved modern gas engine. The old cry of irregular driving is fast passing away as regards these modern gas engines, and although by the use of electricity greater regularity may be secured, the margin is really so slight and the cost of gas is so low that to meet the competition the electrical engineer will have to bring all his forces into what will develop into a triangular fight between steam, electricity and gas.

As already stated, there is now an increased understanding amongst electrical engineers of the requirements of the textile industry, and later in this article the writer hopes to bring home to readers the fact that electricity has not only come to stay, but to take a foremost place in many branches of textile manufacture, quite apart from its position as the

driving-power unit. Electricity has been employed in many different ways and in many different processes, and although it has been applied to a number of machines connected with spinning and weaving there can be no doubt that we are only on the fringe of the possibilities of its application. While not advising engineers to neglect the main problems of driving, it is very necessary that they should also apportion a certain amount of their endeavours to experimenting in connection with special applications. For instance, as will be described and illustrated later in this article, electricity has been applied to damask weaving in such a manner that not only is a considerable saving in time effected, but the cost of production is very materially reduced. This is only one case; there are others, and in course of time, with constant application, there will be an almost indefinite number of special applications which will minimise labour, economise time, and generally reduce the cost of production.

It is hardly possible to avoid repetition in an article of this nature with regard to what has already been accomplished, but the writer will endeavour to transgress as little as possible in this direction.

Before dealing with general systems of driving by electricity it will be best to refer to the conditions prevailing in the great majority of textile mills. In Fig. 2 the method generally employed for the purpose of cotton and woollen mill driving is shown. It will be seen that the various floors are driven by the power of a single main engine being transmitted through ropes. The rope race is more clearly shown in Fig. 3, which is the plan of a card-room and engine-house at the Drake Mill, the machinery of which has been supplied by Messrs. John Hetherington & Sons, Ltd., Manchester. A large fly or rope wheel is employed as shown, and there is no doubt that this system ensures great steadiness of driving. The preparation machinery of the mill (speaking of cotton

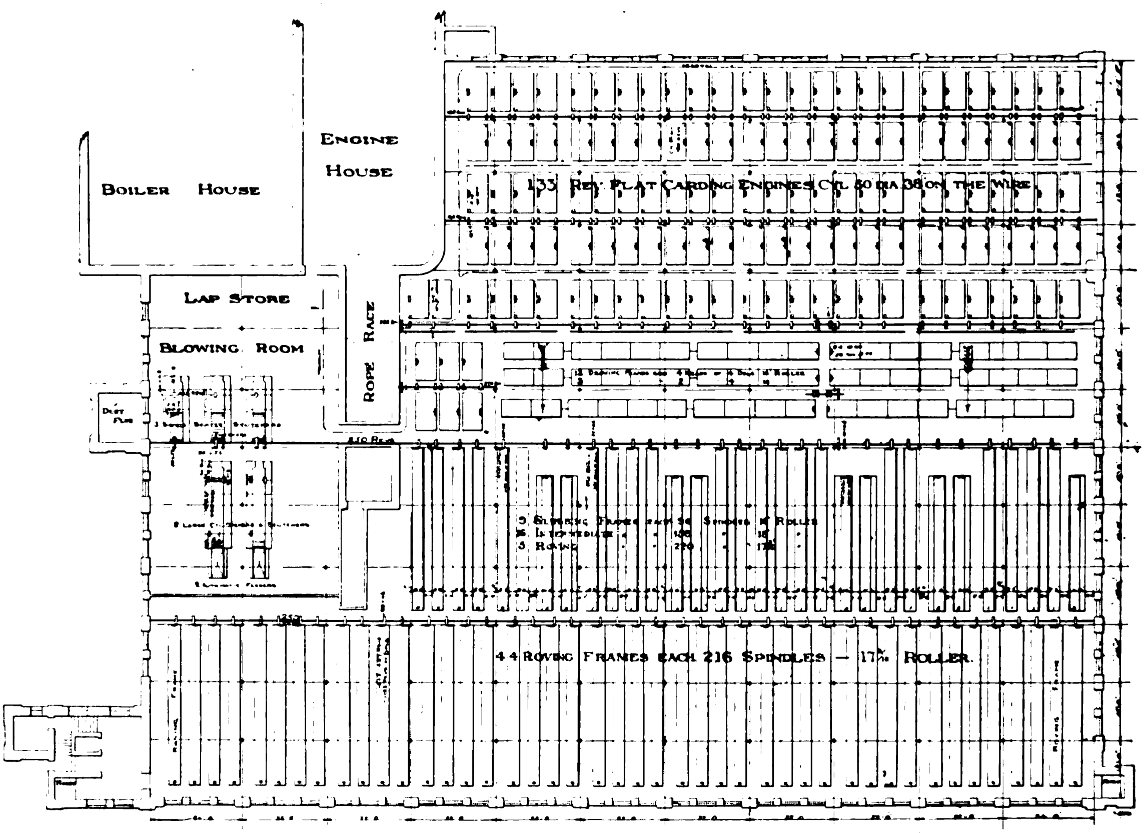


Fig. 3. Plan of Card Room and Engine House.

mills more particularly) is located on the lower floors, the spinning machines on the second and succeeding stories. The cost of a steam-driven plant will approximate as follows, the power being 1000i.h.p., with a rope drive.

Two 500i.h.p. engines and boilers, economisers, superheaters, and all accessories up to flywheel shaft ...	£10,000
Ropes, rope pulleys, and all shafting, with necessary pulleys	£5000
Total	£15,000

The cost per i.h.p. per hour can be placed as low as one-fifth of a penny for a mill spinning medium counts.

The following table shows the approximate power required to drive each machine in a cotton mill.

TABLE I.

Cotton Gin (single)	1	h.p.
,, ,, (double)	1¼	..
Bale opener	2	,,
Mixing lattices	1	.. per 100ft.
Automatic feeder	1½	,,
Porcupine feed table with 6ft. of lattice 36in. wide	1½	,,
Crighton opener (single)	5	,,
,, ,, (double)	10	,,
Combined single Crighton opener and single scutcher	9	,,
Combined double Crighton opener and single scutcher	14	,,
Buckley single opener and single scutcher	9	,,
Single scutcher	4	,,
Double scutcher	8	..
Carding engine R.F.	¾	,,
Roller and clearer carding engine	1	,,
Comber lap machine	⅝	,,
Ribbon lap machine	1⅛	,,
Derby doubler 10in. lap	¾	..
,, ,, 19in. ,, . ..	⅞	,,
,, ,, 37in. ,, ...	1	,,
Heilmann comber 6 heads	⅓	,,
,, ,, 8 ,, ..	½	,,
Nasmith ,, 4 ,, . .	⅓	..
,, ,, 5 ,, ...	½	,,
,, ,, 6 ,, ...	⅝	,,
Draw frame	14	deliveries per 1h.p
Slubbing frame .. .	50	spindles per h.p.
Intermediate frame ..	60	.. ..
Roving frame..	70	.. ..
Fine jack frame	80	,, ,,
Self-acting mule	1h.p.	for 100 to 120 spindles according to gauge.
Ring spinning frame ..	90	spindles per 1h.p.
Doubling winding frame	100	drums per h.p.
Ring doubler	35	to 50 spindles.
Single cop reel	20	to 1 h.p.
Double cop reel	10	,, 1 ,,
Bundling press		1½ ,,

It may be reckoned that by adding 20 per cent. to the total h.p. for friction losses, &c., from the engines to the driving shafts of the machines the total h.p. of the engine requisite for driving the whole mill is obtained.

The figures below give the power required to drive plain looms, employed in weaving calicoes, and the necessary preparation machines are given. Winding frames are not included, as the power required to drive them is given in the table (I.) preceding this.

TABLE II.

Beaming machine	·30	h.p.
Size-mixing apparatus	2½	,,
Slasher sizing machine	1½	,,
Plain loom	·16	,,
Plaiting machine ..	¼	.
Cloth press	1½	,,

It cannot be too often impressed upon the textile trades that electricity possesses numerous advantages, amongst which the following are chiefly important.

Either group or individual driving can be employed, parts of the same mill being differently driven; for instance, where large finishing machines are employed in conjunction with a weaving shed, the latter can be driven from shafting direct-coupled to motors, while the former can be driven individually.

The regularity of the drive obtained from the use of electricity has long been recognised. This is extremely useful in connection with fine spinning.

A continual check on the power consumed can be exercised both in the aggregate and for each department or machine.

Both power and light can be obtained from the same circuit, thus simplifying constructional details besides being extremely convenient.

Whether it is better to generate the electricity at the mill itself or to purchase current will have to be settled in each and

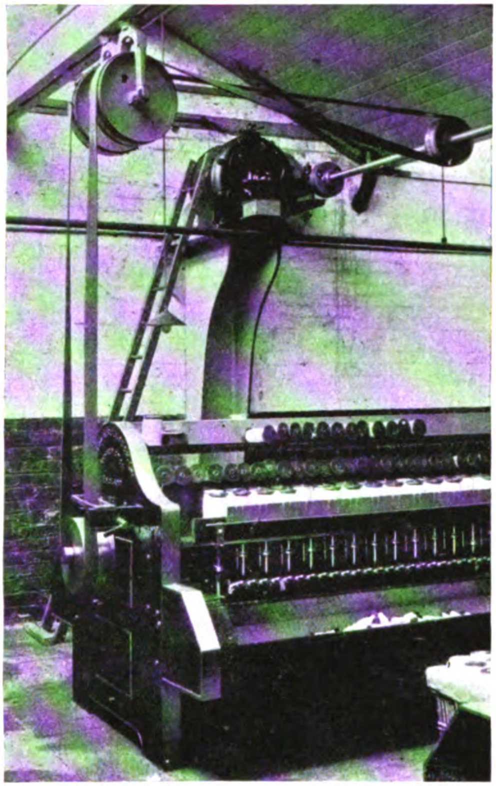


FIG. 4. $7\frac{1}{2}$H.P. MOTOR DRIVING WINDING FRAME.

every case. So many factors enter into the solution of this question that it will be better to make a thorough investigation before deciding. In the majority of cases, however, we should consider it would be better that the mill should generate its own electricity.

In the following descriptions of various electrically driven mills and the application of electricity, the writer has endeavoured to obtain particulars of drives applied to all branches of the industry, and to treat those special cases in which electricity is being used in an entirely novel manner.

In the Premier Mill at Stalybridge, which has been equipped by the British Westinghouse Company, Ltd., one is immediately impressed by the uncommonly bright airy appearance of the various departments. The mill is almost unique, being built on the shed principle, the departments succeeding one another in such a manner that the cotton is constantly passing forward, thus facilitating handling, avoiding any confusion, and speeding up work generally. In this mill the power is purchased, three-phase current being supplied from the Stalybridge, Hyde, Mossley, and Dukinfield Joint Boards' main generating station, whence it is transmitted at a pressure of 6000 volts to the mill. The supply pressure is reduced to 400 volts at the mill by means of three 250kw. Westinghouse transformers, and distributed to the motors in the mill at this pressure, the control of the various circuits, as well as the transformers, being carried out by means of a Ferranti switchboard.

The motors are of the induction type, and wherever the conditions will permit, a squirrel-cage rotor is employed. This is the case in all instances except with the two 150h.p. motors operating ring spinning frames and roving frames; these large motors are of the slip-ring type. The squirrel-cage motors, of course, offer great advantage in that there are no rubbing contacts or other parts whatever between

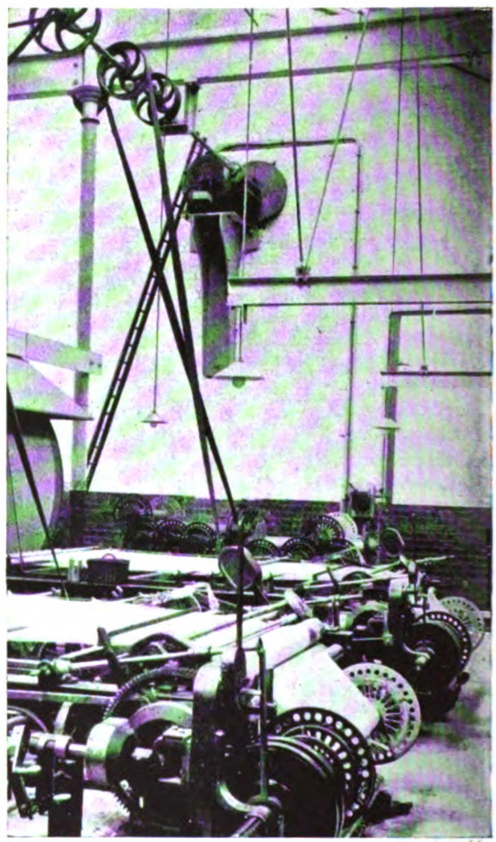


FIG. 5. 15H.P. MOTOR DRIVING SIZING MACHINE.

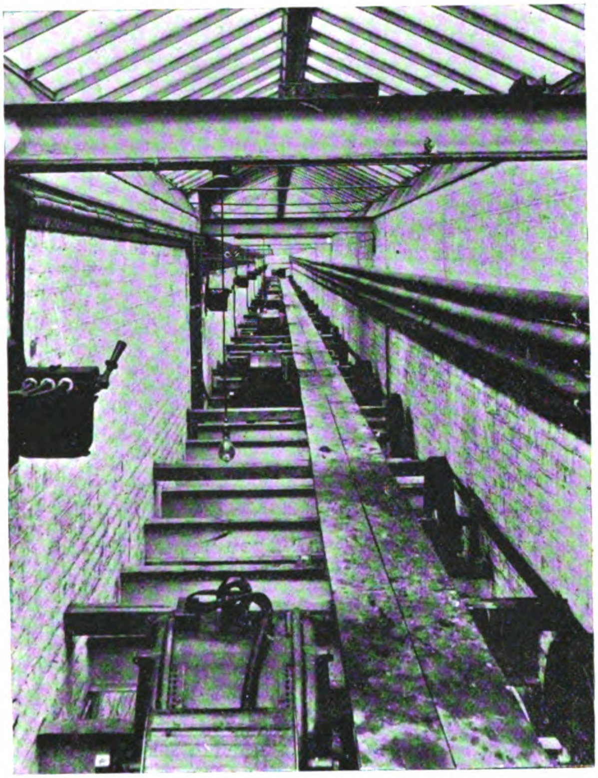


FIG. 6. MOTOR ALLEY IN COTTON MILL, AS SEEN ABOVE THE MOTORS.

the rotor and the stator other than the journals, whereas with the slip-ring machines current has to be collected from the rotating part by means of brushes bearing on rings; these brushes and rings are, however, entirely enclosed, and the collector rings being continuous, no commutation or circuit changing takes place thereon: thus sparking is impossible, and attendance and wear and tear are minimum.

One motor serves to drive the entire machinery in the blowing room as well as the bale-breaker and carrying lattice, which are in an adjoining room; the motor is a 40h.p. squirrel machine. Another similar motor, but of 60h.p. capacity, drives the carding machines and drawing frames. In Figs. 4 and 5 a $7\frac{1}{2}$h.p. and 15h.p. squirrel-cage motor are shown respectively, both running at 580r.p.m., driving winding frames and sizing machines. In the weaving shed the motors are direct-coupled to the cross shafts, the speed of the shafts being 570r.p.m. Fig. 6 gives a view of one of the motor alleys taken above the motors, and in Fig. 7 a view of the lower portion of the alley is shown. It will be seen how advantageously the space is used. Runways are fitted up along which the cotton in various stages of manufacture can be supported and traversed. The mill is electrically lighted throughout.

One of the great advantages of the electric drive is that in the majority of cases it can be applied to individual machines without any alteration being made in the design or construction of the machine itself. For instance, in adapting ring spinning and doubling frames, Messrs. Brooks & Doxey, of Union

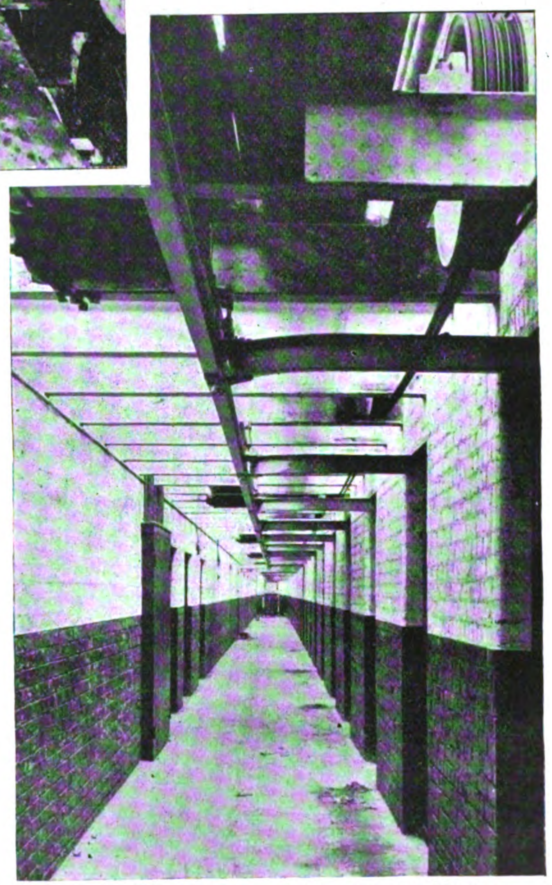


FIG. 7. MOTOR ALLEY. VIEW BELOW THE MOTORS.

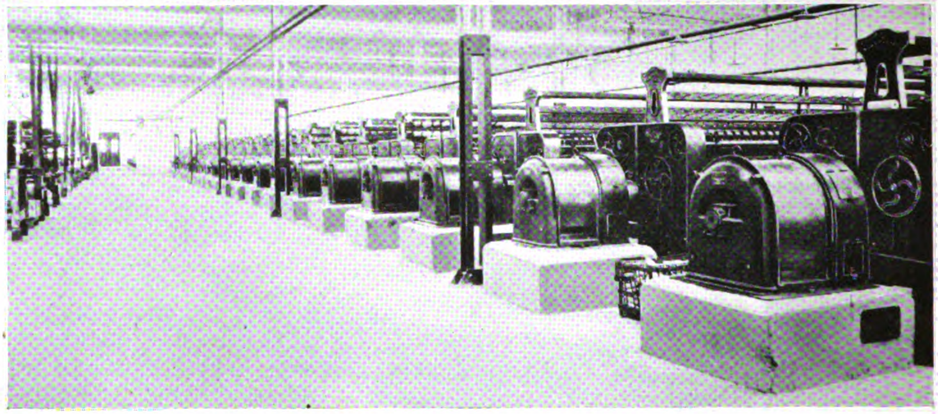


FIG. 8. DOUBLING FRAMES DIRECT DRIVEN BY SINGLE MOTORS.

Ironworks, West Gorton, Manchester, inform us that the only alteration they make in their machines is that they remove the small guard frame-end and apply one-half of the coupling for connecting the motor direct to the driving shaft of the machine. This company have supplied a great number of machines to Continental spinners, which are being electrically driven, and in the illustrations marked Figs. 8 and 9 the ring room and the motor driving the card room at the mill of Messrs. Act. Gesellschaft vormals J. Paravicini, Landeck, Tyrol, are shown. The whole of the machinery which is detailed below was supplied by Messrs. Brooks & Doxey, and the electric installation by Messrs. Brown, Boveri, & Co., of Baden, Switzerland. There are thirty-six ring frames of 440 spindles each, and four doublers of 320 spindles each, and eighteen doublers of 352 spindles each.

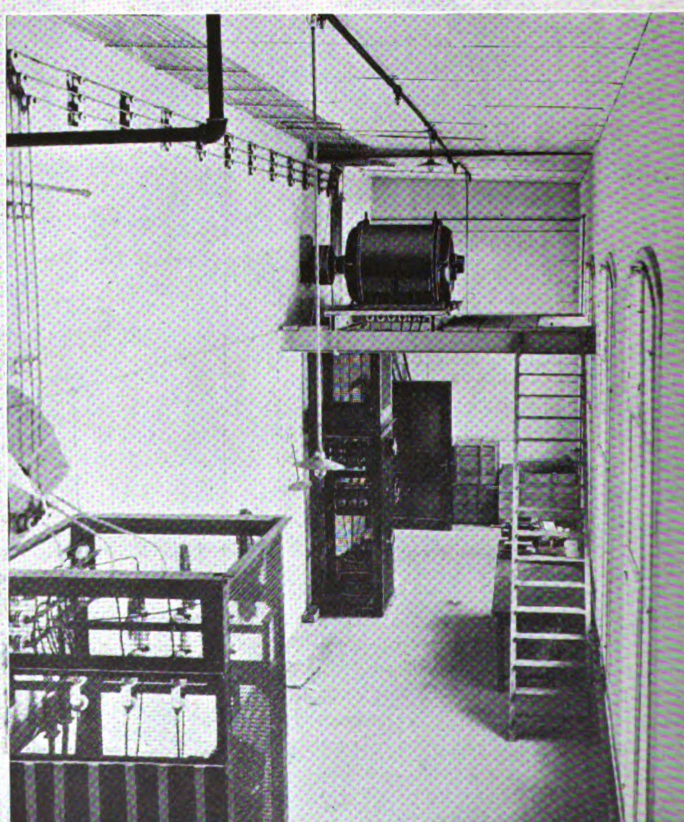


FIG. 9. DRIVING MOTOR FOR CARDROOM AND SWITCHBOARD.

FIG. 10. EXTERIOR OF MILL IN PORTUGAL, ELECTRICALLY DRIVEN.

The machines are direct-driven, as will be seen from the illustration Fig. 8. The power of each motor for both spinning and doubling frames is 8h.p., the tension of the current being 400 volts. The highest speed of the motor is 800r.p.m., and the lowest speed 600r.p.m., but the efficiency of the motor is not affected by the change in speed. Of course, the motor can be run at various speeds from 0 to 600 at starting. The average speed the motors are running at present is 720r.p.m., single-phase current being used. The motors are direct-coupled to the tin roller shaft by means of a flexible coupling, which is so arranged as to prevent the frames starting in a jerky manner. In order to vary the speed of the motor the position of the brushes is altered. In starting up the motors are run at 500r.p.m. to 550r.p.m., and then after about two minutes, when all the ends are up, the speed of the motor is increased to about 720 revs. The capability of changing the speed conveniently, and the ease with which the frames can be started up, are of considerable advantage in doubling, and in this respect the motor has been specially designed to meet the requirements, and no resistance is relied on for the purpose. The carding room and preparation machinery are driven by a three-phase alternating-current motor (Fig. 9) of 80h.p., 1000 volts, 40 periods, and running at 400r.p.m. In the foreground of this illustration the cable distributing switchboard is seen. Messrs. Brooks and Doxey have supplied machines to be electrically driven

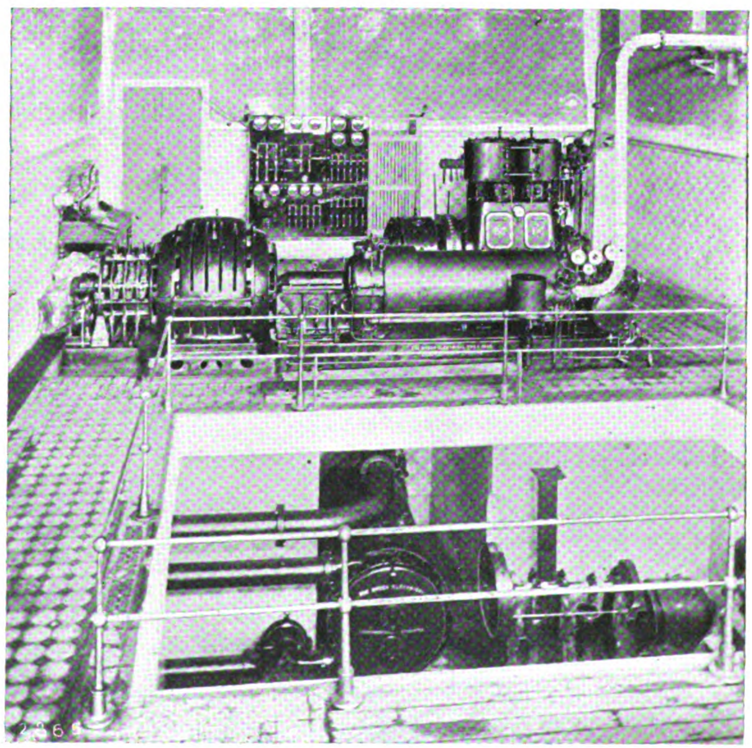


FIG. 11. GENERATING PLANT, SPINNING MILL, PORTUGAL.

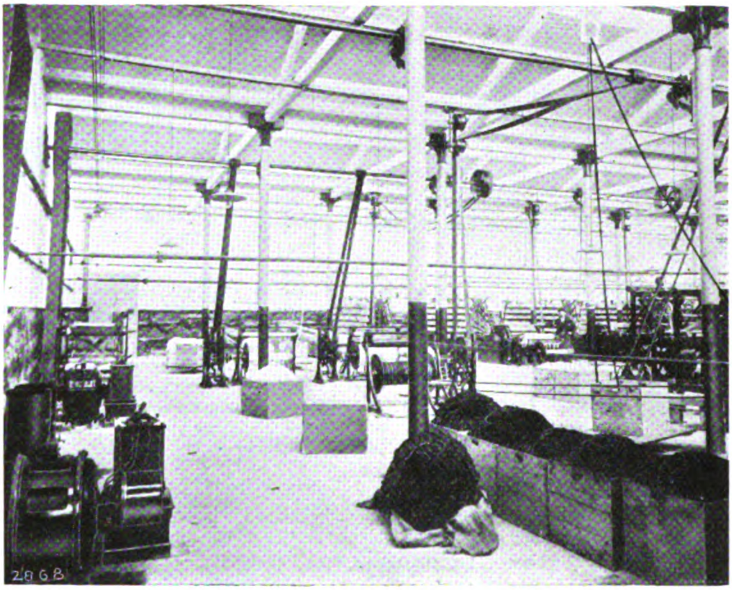


FIG. 12. BEAMING AND WINDING ROOM, MILL IN PORTUGAL.

to the Vernon Spinning Company, of Stockport, twelve ring spinning frames of 432 spindles being installed; also to Messrs. Samuel Moorhouse, Ltd., of Stockport, members of the Fine Spinners' Association, which is an instance that electricity is well adapted to fine spinning; and to Messrs. Andrew & Bramhall, Carruthers Street Mills, Manchester. Messrs. Brooks & Doxey, Ltd., it will be remembered, supplied the whole of the preparation and spinning machinery to the Acme Mill, an illustration of which is given earlier in this article.

It is somewhat curious that the Continental spinners and manufacturers have been very much more ready to adopt the electric drive than have their competitors in this country. There are many examples of complete installations to be found on the Continent, and in nearly every case great satisfaction is being given. We have no figures which show a comparison between steam-driven mills in this country and on the Continent, but we incline to the opinion that Continental mills steam-driven are not run so cheaply as British mills. This is, however, somewhat beside the point. Electricity has been, and is being, largely used on the Continent, and such a mill as that of the Empreza Fabril do Norte, at Oporto, Portugal, is a credit to any country. This mill has been equipped with spinning machinery by Messrs. Dobson & Barlow, Ltd., of Bolton, the boilers have been supplied by Messrs. Adamson, and the generating plant, motors, and switchboard are of the Brush Electric Company's make; so that, although the mill is located abroad, the whole of the plant is of British manufac-

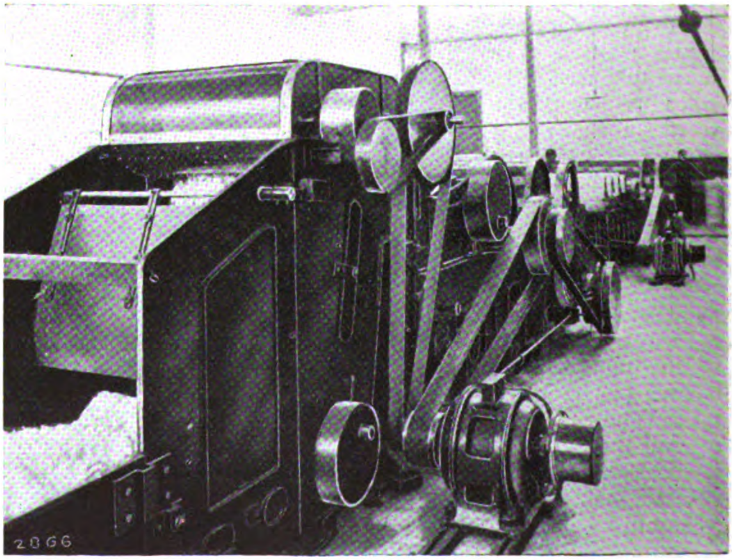


FIG 13. DRIVING OF SCUTCHERS, MILL IN PORTUGAL.

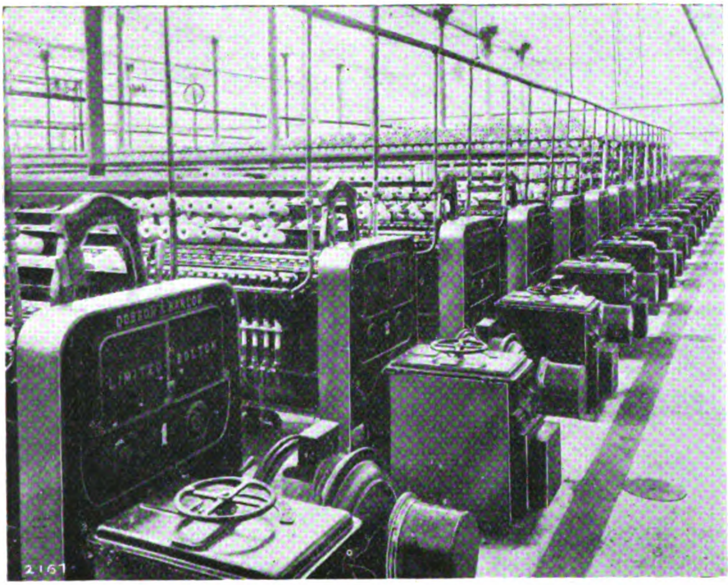


FIG. 14. DIRECT-DRIVEN DOUBLING FRAMES.

ture. This mill possesses a rather unique department in which the bobbins and spools requisite are made. The machinery has been supplied by Messrs. Walter McGee & Sons, Paisley.

From Fig. 10 a good idea of the building employed can be obtained, this view showing a portion of the mill. The generating plant is shown in Fig. 11. It consists of a "Brush-Parsons" 300kw. turbine, the steam being 160lb. pressure, with a superheat of 160deg. F. The generator is of the 500-volt, 50-cycle,

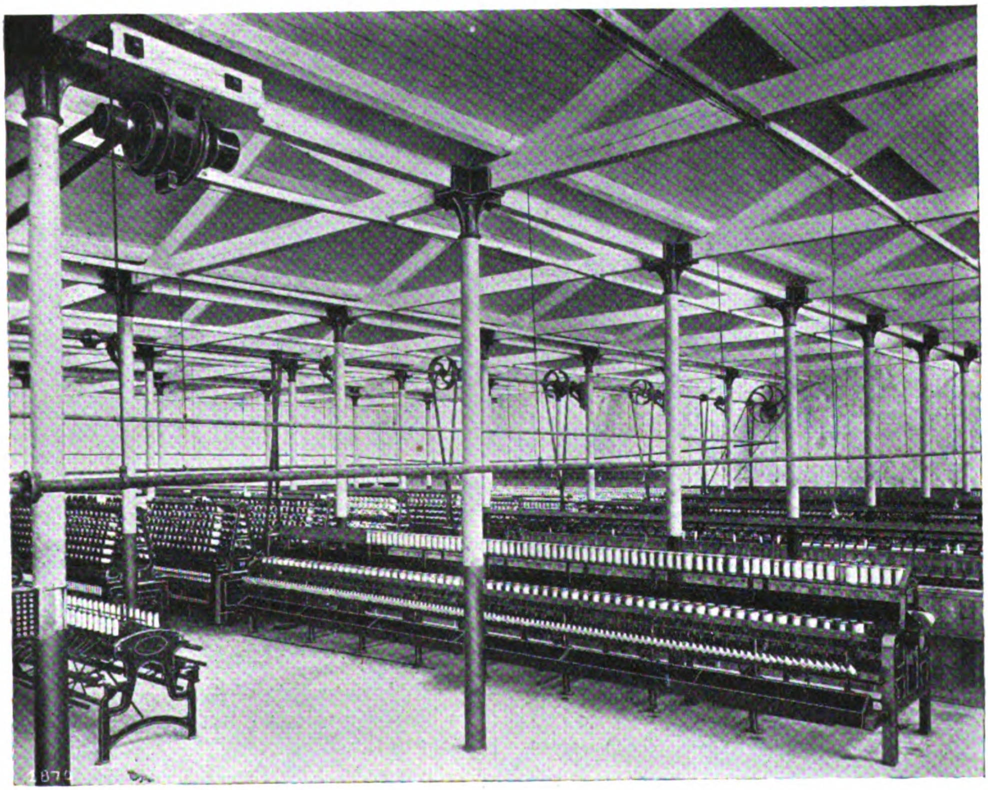


FIG. 15. WINDING ROOM, MILL IN PORTUGAL.

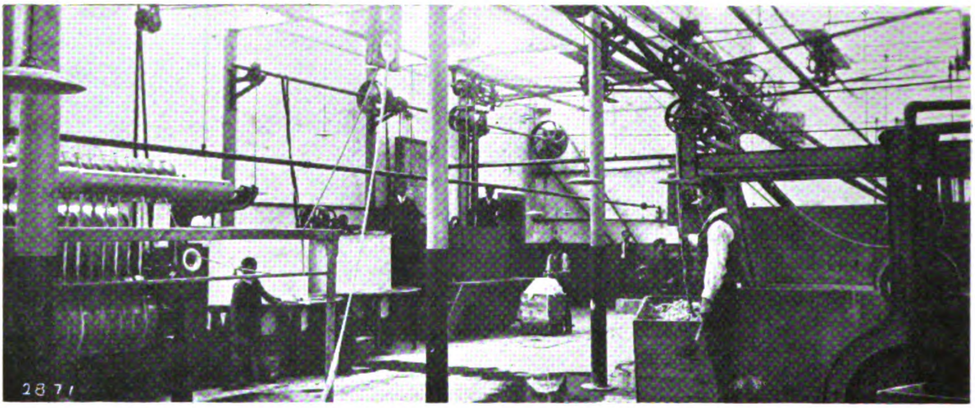


FIG. 16. CORNER OF DYE HOUSE, PORTUGUESE MILL.

three-phase type. The condensing plant is of the brush-surface type, both the circulating and air pumps being electrically driven. The combined reciprocating set shown in the background is driving an 80kw. direct-current generator, the power being used for driving certain direct-current motors throughout the mill, also for the lighting of the mill.

In Fig. 12 two of the motors, each 20h.p., employed for driving the beaming and winding room, are shown. Fig. 13 shows the driving of the scutchers by means of individual motors. In Fig. 14 a portion of the doubling frames which are direct-driven is shown. Fig. 15 shows the winding room, and the small amount of space occupied by the motor and its accessibility are worthy of notice. In Fig. 16 the bleaching and dyeing department is shown. In Fig. 17 the bobbin-making department is shown. It is interesting to note that in connection with this department the wood employed is grown within ten miles of Oporto. As will be gathered, the mill is self-contained, the yarn produced being turned out in a bleached and finished condition. The mill produces sewing thread and is the first of its kind in Portugal. We are informed that there has never been a moment's involuntary stoppage since the installation of the plant, and the success of the mill is such that not only can they supply the whole of the Portuguese market with sewing thread, but they are also exporting to the Brazils.

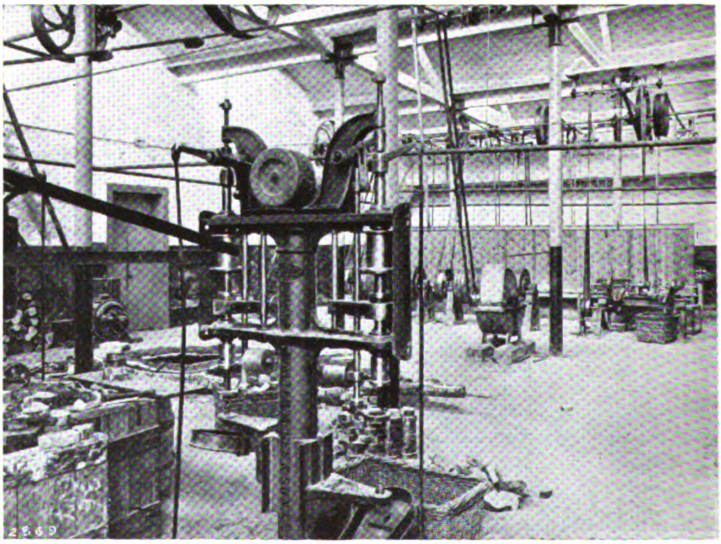


FIG. 17. BOBBIN-MAKING DEPARTMENT IN PORTUGUESE MILL.

(*To be continued.*)

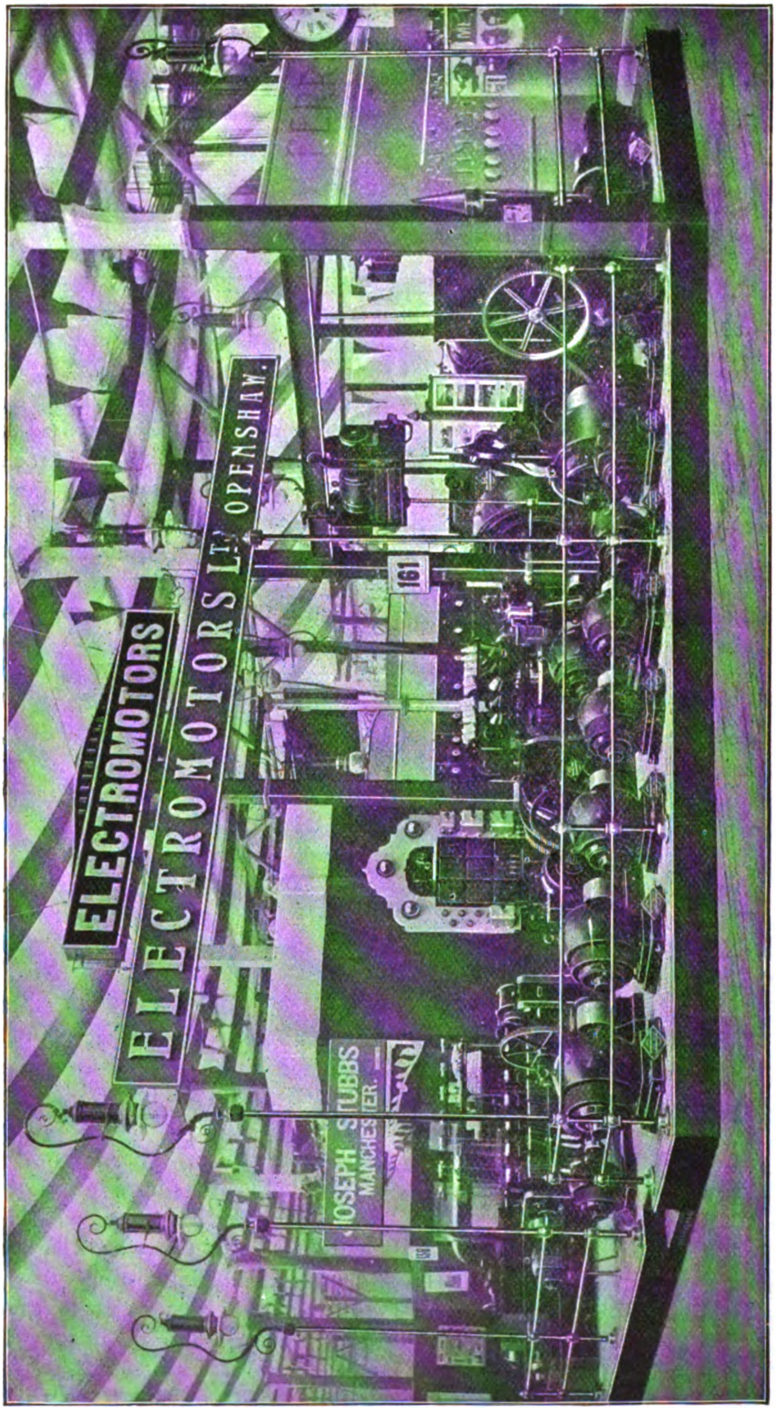
MANCHESTER
Electrical Exhibition.

At the time of writing these notes the Electrical Exhibition has been opened for some days and has fully justified the optimistic opinions generally expressed in electrical engineering circles during its period of development. It is now conceded that this exhibition is the finest which has ever been held in this country in connection with the electrical industry. It is not only the largest of its kind, there being upwards of 250 exhibiting firms but it is certainly the most representative and complete exposition of the immense industrial field now entering into electric light and power practice.

All the exhibits are assembled under one roof, a building covering some 100,000sq. ft. having been specially erected for the purpose on a site lent by the Manchester Corporation. Large as this hall is, there is no space to spare, and, indeed, if any fault is to be found at all it is that a larger hall and a little more walking space would have been an advantage.

Promoted by the National Electrical Manufacturers' Association, the exhibition is directly under the patronage of the Institution of Electrical Engineers, the Municipal Electrical Association, and the Manchester Chamber of Commerce; moreover, it is supported by the Corporations of Manchester and Salford, and also of Accrington, Bolton, Buxton, Bury, Barrow-in-Furness, Bradford, Batley, Barnsley, Blackburn, Birkenhead, Derby, Dewsbury, Eccles, Elland, Halifax, Hull, Heywood, Longton, Lancaster, Middleton, Nottingham, Oldham, Rochdale, Radcliffe, Stretford, Stockport, and Warrington, all ot which boroughs have subscribed towards the funds of the exhibition. Manchester was selected for the purposes of the exhibition in view of its position as the greatest industrial centre in the world, and in consideration of the fact that the city's electricity system is the most extensive in the country. The reason for the exhibition is to demonstrate in a practical manner the great advantages of electricity for both business purposes and private use, and, speaking broadly, there is not a branch of electricity and probably not a department of engineering which is not represented in some form or another in the building.

It is therefore not possible in this number of The Electrical Magazine to do full justice to the large array of exhibits, to the valuable lessons which are to be gathered from a critical survey of the exhibition as a whole, nor to the excellent engineering work which has been carried out by the organizers; these features must perforce be left over until next month for the due and ample notice they merit. The following notices of individual exhibits have been selected rather as being indicative of the great scope covered by the exhibition than as being the largest or most generally interesting. It will be seen from this preliminary view that modern electrical practice, as for commercial and domestic purposes, is represented to the full, and everyone, be he layman or engineer, will be well repaid for time spent in a visit.



The Exhibit of Electromotors, Ltd., Openshaw, and Joseph Stubbs, Manchester.

Electromotors, Ltd.

THIS exhibit is one of the most attractive and extensive in the hall, and demonstrates very fully the facility with which electricity can be applied to the successful driving of every possible class of machine or groups of machinery. In addition to examples of the firm's well-known standard motors, of which a full range of sizes from ½h.p. to 20h.p. is set in the foreground, there are examples of spur reduction gear motors, worm gear motors, &c. The operating plant includes electric pump, fan, haulage, lifting, and other combinations. The firm also exhibits steam and petrol generating sets suitable for pilot lighting in mills, country houses, and ship lighting.

To illustrate the application of electrical driving to textile machinery, two quick-traverse winding frames, of Messrs. Joseph Stubbs' manufacture, for winding cotton and other yarns are shown working under ordinary normal conditions, each machine being directly controlled and operated by an electric motor.

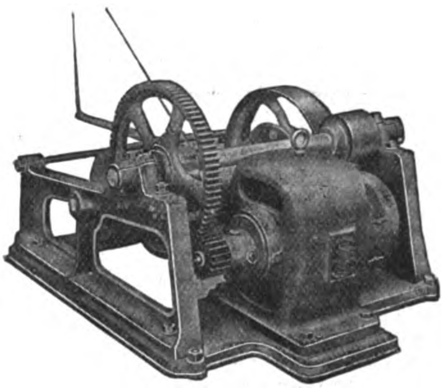


FIG. 1. ELECTROMOTORS HOIST.

A particularly noteworthy feature of the exhibit is the use of a special automatic switchboard, which is so arranged as to operate automatically throughout the day some twenty motors and motor combinations in pairs. One pair of motors starts up, runs for thirty seconds, stops, and another pair automatically starts up, and so on through the entire series. Simultaneously illuminated signs bearing a description of the running pair light up and go out, drawing additional attention to the running machines, and thus making an original and very attractive display.

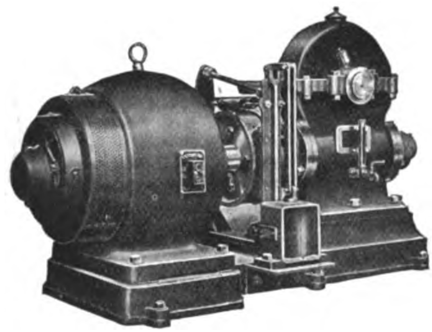


FIG. 2. LIFT-GEAR COMBINATION.

Another feature compelling attraction is a fine "Luxol" sign, bearing the name "Electromotors" in large letters, facing each way. The sign is very well finished, and reflects credit upon Messrs. Krupka & Jacoby, who supplied it.

The many fine examples of electrically driven plant shown are so numerous as to permit of only a brief mention of each. The following main particulars will, however, give an idea of the scope covered by the products of this progressive firm :—

A 20h.p., 850r.p.m. standard spur reduction gear motor, reducing to 170r.p.m. on its second motion shaft by means of a self-contained gear.

A 3¼kw. motor generator consisting of two machines coupled together on a common bedplate. This type of combination is specially suitable for boosting or transforming voltages.

A 3h.p. motor fitted with an enclosed worm-reducing gear, with ball-thrust bearings and phosphor-bronze wheel rim, reducing from 1100r.p.m. to 50r.p.m., the motor and worm gear being mounted together on a substantial bedplate. This combination is

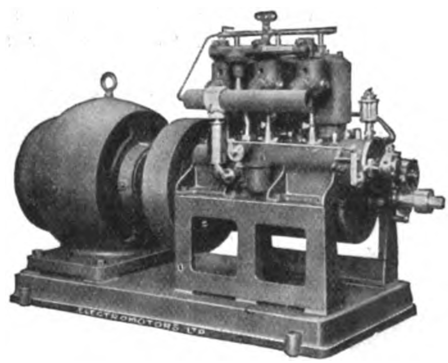


FIG. 3. PETROL-ELECTRIC SET.

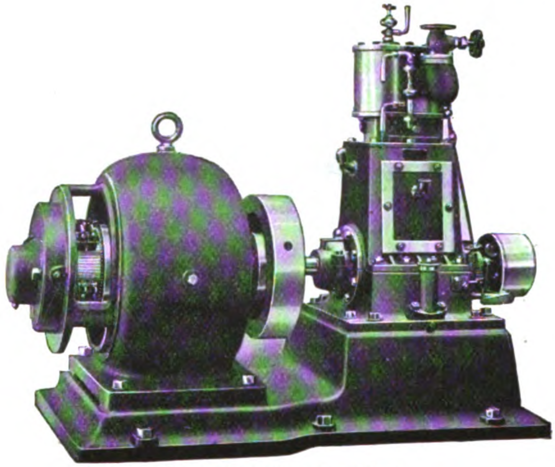


FIG. 4. SMALL STEAM-ELECTRIC SET.

specially adapted for the driving of economisers, stokers, organ-blowing, and the driving generally of very slow-speed shafting and machinery.

A $4\frac{1}{2}$h.p. lift gear combination, comprising an interpole motor and worm reducing gear, as described above, and a special automatic brake situated between the motor and the worm gear designed to bring the lift to rest immediately the current is cut off. This is the firm's standard lift equipment for passenger, goods, or service lifts, and can be supplied with any of three systems of control—hand rope; ordinary push button control with attendant; push button control without attendant.

A petrol dynamo set for private house lighting by means of a battery and low-voltage metallic-filament lamps. Also a 3kw. steam dynamo, 410r.p.m., of which the engine is of the $4\frac{1}{2}$in. by 4in. open vertical high-speed double-acting type, and is direct-coupled to a compound-wound dynamo on a combination bedplate. These sets are standardised from 1kw. to 30kw. for all steam pressures, as well as a similar range with high-speed enclosed-type engines.

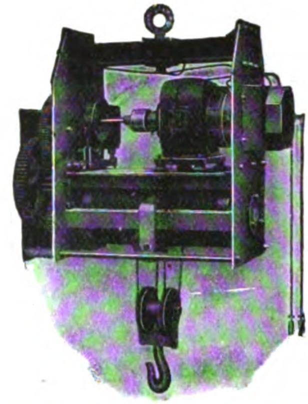


FIG. 6. ELECTRIC PULLEY BLOCK.

They are in good demand for ship and private house lighting, and are well adapted for pilot sets in textile mills and large factories.

A 5cwt. friction hoist designed to work at 100ft. per minute is driven through a combined spur and friction gear by means of a compound-wound motor. These hoists are largely used in warehouses, provision stores, and in engineering shops and factories generally.

A main drum haulage set capable of hauling at four miles an hour, direct-driven through gearing by a 5h.p. motor, 850r.p.m. This equipment is worked by a reversing drum controller, with jaw clutch for disengaging the drum and a powerful foot-brake. These haulage gears can be supplied in varying sizes, and are designed for hauling up inclines in which the gradient exceeds 2in. to the yard. Main-and-tail haulages and endless rope gears are also standardised.

A one-ton electric pulley block, worked by self-contained motor, illustrates another of the firm's specialities. They can be supplied of the suspension type, with hand

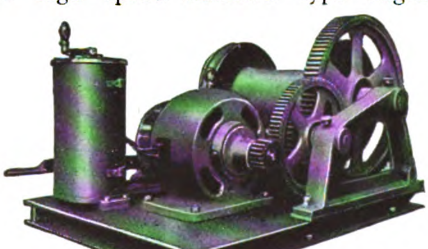


FIG. 5. ELECTRIC HAULAGE GEAR.

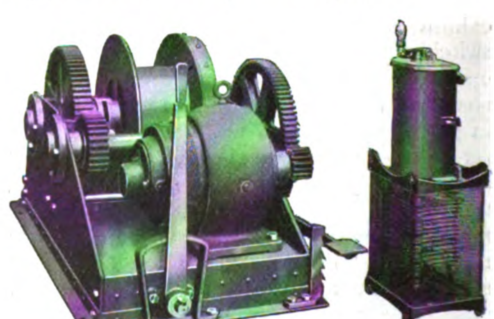


FIG. 7. ELECTRIC HAULAGE GEAR.

travelling gear or motor travelling gear, for running on the flanges of a single H girder, making an ideal runway for workshops, warehouses, chemical works, and the like.

Other exhibits include electrically-driven centrifugal and ram pumps, and electrically-driven cased and propeller fans, portable drills, buffing and grinding machines, &c.

Portable Electric Tools.

THE exhibit of the Consolidated Pneumatic Tool Company comprises a number of portable electrically driven tools suitable for drilling, reaming, tapping, tube-expanding, grinding, and similar operations.

The drilling machines, which range from small breast drills capable of drilling holes $\frac{3}{8}$in. dia. in steel to large machines capable of drilling $2\frac{1}{2}$in. to 3in. in steel, and a number of intermediate sizes, practically cover the entire range of tools required by engineers and shipbuilders for the work that they generally have to do.

The outstanding feature of these machines is their strong mechanical design, the lack of which, as is well known, is the chief source of trouble with portable tools which are exposed to a great deal of rough treatment. It is now generally conceded that electric tools give all the advantages of pneumatic tools so far as economy of labour is concerned, with the additional advantage that considerable economy in power is possible. It has been found by several investigators that the distribution of power by compressed air for portable tools involves from four to five times as much power at the air compressor as is required with electric tools to do the same amount of work.

FIG. 2. PEDESTAL ELECTRIC GRINDER.

Improvements in design introduced by the Consolidated Pneumatic Tool Company have reduced the maintenance charges of electric tools to a figure quite comparable with pneumatic tools and possessing the additional advantage that economy in the cost of power is secured. As indicating the popularity of these tools, it is interesting to learn that one of the leading shipbuilding firms in the country use no fewer than thirty of the Consolidated Pneumatic Tool Company's machines, and their use is rapidly extending all over the country. Fig. 1 shows one of the machines adapted for drilling on tramway or railway

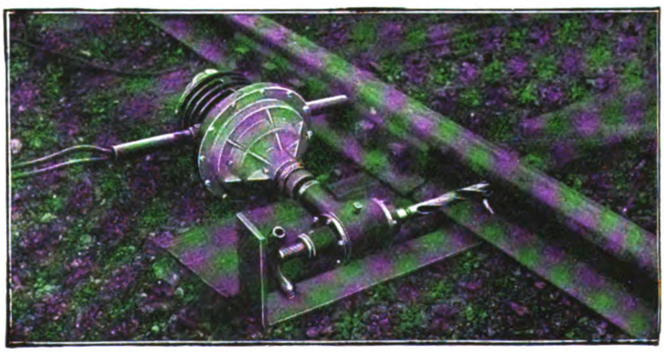


FIG. 1. PORTABLE ELECTRIC RAIL DRILL

tracks, such as for bonding, &c., while Fig. 2 shows a pedestal grinding machine, which, by the way, is now largely used by engineers for grinding tools. The company's portable grinder is also largely employed for fettling castings and similar work which was formerly done by pneumatic power. Another speciality shown at this stand are the electro-magnetic drill posts, which, of course, can be fixed to any iron or steel surface by merely turning a switch, and in this respect save the cost of bolting the pillar to the work as was formerly done.

Hart Accumulators.

THE exhibit of the Hart Accumulator Co., Ltd., is a very complete one, including specimens of a very wide range of batteries designed for particular services. A complete battery of 30 "1908" lighting type eleven-plate cells is shown erected on two-tier wood stands; these have a maximum capacity of 300 ampere-hours.

The cells are supplied complete with glass boxes, trays, acid, oil, insulators, glass spray arresters, and are fitted with patent non-corrosive terminals. Copper rod connections are shown joined to the cells, and the maker's patent sheet separators are used, which prevent internal short circuits and render it unnecessary for the attendant to regularly examine the cells; no weekly examination is necessary with these separators, there is no irregularity in the working, and it is claimed that the life of the cells is increased and buckling prevented. The plates are spaced widely apart with $\frac{9}{16}$in. diameter glass separators and there is a clearance beneath the plates of $3\frac{1}{2}$in., so avoiding the necessity for periodically cleaning out the cells. These batteries can be supplied in glass boxes for capacities ranging from 120 to 960 ampere-hours; above this size, wood lead-lined boxes or lead tanks are used. Another exhibit is a battery of 6 "CL" type cells in glass boxes, complete with all accessories, mounted on wood stands. A clearance of 6in. is provided beneath the plates, and $\frac{9}{16}$in. diameter glass separators are used. These cells are specially suitable for central station work, and can either be fitted with solid lead-burnt connections or the patent non-corrosive terminals. The maximum size that can be supplied in glass boxes has a capacity of 1045 ampere-hours; above this size, either lead or lead-lined boxes are used.

Only brief mention can be made of the several other types of accumulator exhibited on this stand. These are as follow:—

"CL" type cells in wood lead-lined boxes. These cells are supplied in any size ranging to 3000 ampere-hours capacity, and are suitable for traction and power stations. This type is largely used for "buffer work" in conjunction with automatic reversible boosters.

"CS" type cells in wood lead-lined boxes. These are suitable for high and rapid discharges for central stations, and are used with or without automatic reversible boosters.

"LCS" cells in wood lead-lined boxes. These are similar to the "CS" and "CL" types, but are much deeper, and are used where only small floor space is available. They can be charged and discharged at rapid rates, and are supplied very extensively for central stations.

"T" type cells in glass boxes. These are similar in design to the "L" type cells, and are intended for use when the capacity of the smallest lighting type is too large. They are supplied for small private installations and similar purposes, telephones, telegraphs, &c.

"S" type cells in glass boxes. These are used for the smallest installations, and are specially suitable for all purposes where small outputs are required. The standard sizes range from 9 ampere-hours upwards.

"T" type cells in wood lead-lined boxes. These are made for portable work of all descriptions, such as telephones, phonographs, temporary lighting installations, portable lamps, &c. The plates will withstand rough usage and are fitted in strong teak boxes with special lids, which prevents spilling of the electrolyte.

"S" type portable batteries. These are suitable for carriage lighting, induction coils, laboratories, hospitals, small lamps, telephones, and similar purposes.

"L" type cells in wood lead-lined boxes. Supplied for private yacht lighting in strong teak boxes, with special lids to prevent the electrolyte washing out. The standard capacities range from 120 to 960 ampere-hours.

Ignition batteries for motor cars, launches, and models. These cells are fitted in strong celluloid boxes with sealed lids, vent plugs, and non-corrosive terminals. The standard sizes range from 4 ampere-hours up to

200 ampere-hours at 2, 4, 6, 8, and 10 volts. A number of different sizes and types are shown.

Other general exhibits include samples of plates of all types in various stages of manufacture; sample patent sheet separators, which prevent internal short circuits and increase the life of the cells; ampere-hour meters, hydrometers, voltmeters, and other instruments required for working storage batteries; and numerous sizes of plates are shown suitable for fitting to boxes of other makes where the plates are worn out and require to be replaced.

Motors for Special Purposes.

THE Lancashire Dynamo and Motor Company, Ltd., exhibit a number of examples of their motor specialities. One of these is of the short-circuited rotor induction type, having an output of 25h.p. on continuous rating at 720r.p.m. on a 400-volt, 50-period, three-phase circuit. This machine is of the semi-enclosed type and is fitted with helical backgear having a 7.4 to 1 ratio. The pinion is of forged steel, and the spur wheel of cast iron. Attention is drawn to the construction of the rotor. Copper discs with radial arms are connected to the rotor rods: by this means a large cooling surface is obtained and the radial arms act as fan blades. Another special point is the method of attaching the core plates to the spider to ensure the tightness of the core, so that it will withstand shock and vibration, there being no bolts and nuts to work loose.

A standard semi-enclosed shunt-wound backgeared motor shown is capable of developing 18b.h.p. continuously on a 400-volt circuit at a speed of 800r.p.m. It is fitted with helical backgear having a ratio of 7.5 to 1, and similar to the foregoing.

Of exceptional interest is the flywheel equalising set (Kelsall and Warburton patent). This set is designed to equalise the load on the main generators by taking up the peaks. It is so arranged that at times of light load the set takes power from the line to raise the speed of the flywheel, the stored energy in the flywheel being used to drive the set as a generator, giving off energy to the line in the event of sudden heavy load calls. This action is instantaneous and the generator current is kept

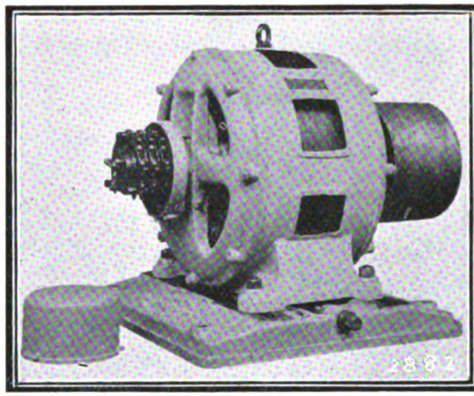


Fig. 1. Three-phase Slip-ring Motor.

practically constant. The set really acts as a buffer taking all sudden variations of load. It is most suitable for traction and varying power loads when the peaks are of sudden and short duration.

There is also shown a motor-driven winch, consisting of a standard motor driving a $1\frac{1}{2}$-ton winch built by Messrs. T. Broadbent & Sons, Ltd., Huddersfield. The motor is capable of developing 38b.h.p. on half-hour rating at 345r.p.m. on a 400-volt circuit. The winch frame is built up of steel sections so disposed as to conveniently carry all the gearing, motor, controller, brake, &c., so making the winch self-contained. The gearing is single-purchase,

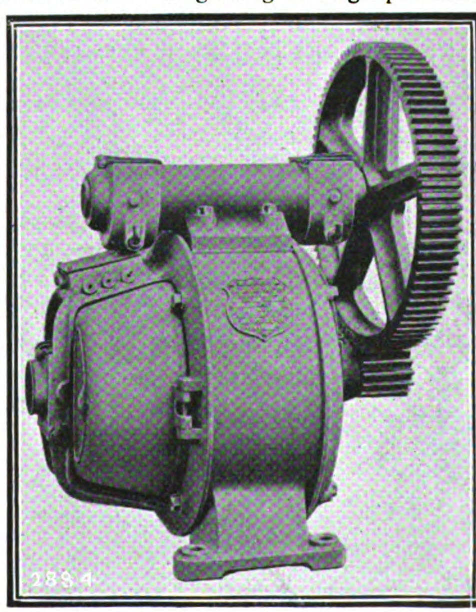


Fig. 2. Back-geared Motor.

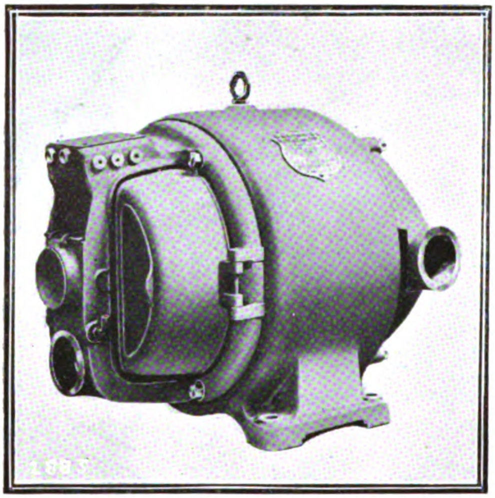


FIG. 3. PIPE VENTILATED MOTOR.

consisting of a mild steel pinion on the motor spindle gearing into a cast-iron spur wheel on the winch barrel. The motor is fitted with an electric solenoid brake, and in addition the winch barrel is also fitted with a brake worked by a foot lever.

An electric fan is exhibited, and consists of a standard semi-enclosed 4-pole motor driving a "Sirocco" upcast fan at a speed of 820r.p.m., at which speed the fan is capable of handling 8000 cubic feet of air per minute, the motor developing 4b.h.p. The fan impeller is keyed direct on the motor shaft, the motor being mounted on an extension of the bedplate that carries the fan.

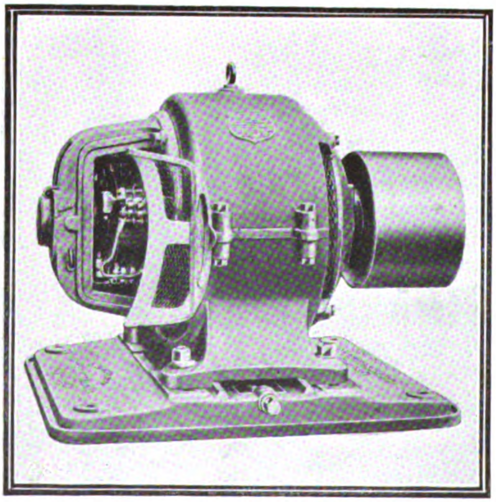


FIG. 4. SEMI-ENCLOSED D.C. MOTOR.

There are several other types of motors shown, as follow :—

A standard 4-pole motor which has the apertures in the end plates fitted with double brass gauze, fine mesh. This special type of enclosure makes the motor most suitable for use in textile factories and dusty places, and fulfils the requirements of the insurance companies.

A standard shunt-wound totally enclosed pipe-ventilated variable-speed interpolar motor, on which a speed variation of three to one or more is obtained by shunt regulation only, sparkless commutation being ensured by the employment of commutating poles. The motor is capable of developing its full load output, viz., 4b.h.p. at any speed between 370r.p.m. and 1120r.p.m. This motor embodies the latest design of end covers for use with pipe ventilation in hot or dusty situations.

A standard semi-enclosed shunt-wound motor of 20h.p., 365r.p.m., 220 volts. This is typical of the larger size of semi-enclosed machines made by the company, and has split magnets to facilitate handling.

Special Cables.

THE exhibit of the Liverpool Electric Cable Co., Ltd., includes a selection of their vulcanised rubber cables of all kinds, showing the various standard qualities and different coverings, and also a series of special forms, of which a noteworthy type is the special hard-cord braided twin cable, designed and introduced for very rough use, particularly for trailing cables in mines and for wharf and theatre use.

There are also shown specimens of the raw materials used in the manufacture of rubber cable, and a number of coils of cable arranged to show the different stages in the manufacture of an electric cable. Other exhibits include various types of flexible wires and cords, together with silk and cotton covered instrument and dynamo wires, samples of fire-resisting cables, &c. The cables exhibited are all of British manufacture, and it would seem from a survey of the exhibit that the company has made rapid strides in the short time it has been in existence, as shown by the number of corporations, railways, &c., who are customers of the firm.

Electric Pumps.

FRANK PEARN & Co., Ltd., are showing types of their well-known Pearn electrically driven pumping sets and also of the latest design of patent high-speed surfacing and boring machines as made by this firm, the whole of the exhibit being shown in operation under working conditions. The stand itself is one of the most prominent in the exhibition. It covers an area of 400 sq. ft., and has frontages on three avenues.

Facing one avenue is arranged a horizontal three-throw ram pump with externally packed rams each 6in. in diameter. The stroke of the pump is 8in. and its capacity 9600 gallons of water per hour to a height of 600ft. or a pressure head of nearly 300lb. The ram barrels and valve chambers are cast separately and are interchangeable. The rams are secured to crossheads moving in guides; the gearing is machine cut, and the shafts and connecting rods are machined from solid forgings (these constructional details are applicable to all the pumps exhibited). The pump is driven by a 35h.p. Westinghouse motor running at 750r.p.m.

Facing the cross-avenue is a vertical three-throw ram pump with externally packed rams, each 6in. in diameter with a stroke of 8in. The capacity of this pump is the same as the foregoing, but owing to limitations of electric power supply, it is shown coupled to a British Thomson-Houston motor of 17½h.p., running at 600 revs. per minute.

On the same frontage is a vertical double ram pump with externally packed rams, each 4in. in diameter and 6in. stroke. This pump is capable of delivering 2560 gallons per hour to a height of 220ft., and is driven by a 4h.p. General Electric Company's motor, running at 1000 revs. per minute.

Fronting the third avenue there are two other electric pumps, one a three-throw and the other a single-throw pump. The three-throw pump has externally packed rams, each 4in. in diameter, 6in. stroke, and a capacity of 3840 gallons per hour at a height of 330ft. This is driven by a 9h.p. General Electric Company's motor, running at 1000 revs. per minute.

The single-throw pump has an externally-packed ram 2in. in diameter, with a 3in. stroke and a capacity of 270 gallons per hour at a height of 100ft. It is driven by a ⅞h.p. Electromotors motor running at 1000r.p.m.

A novel feature of all the vertical pumps shown is that the ram barrels and valve

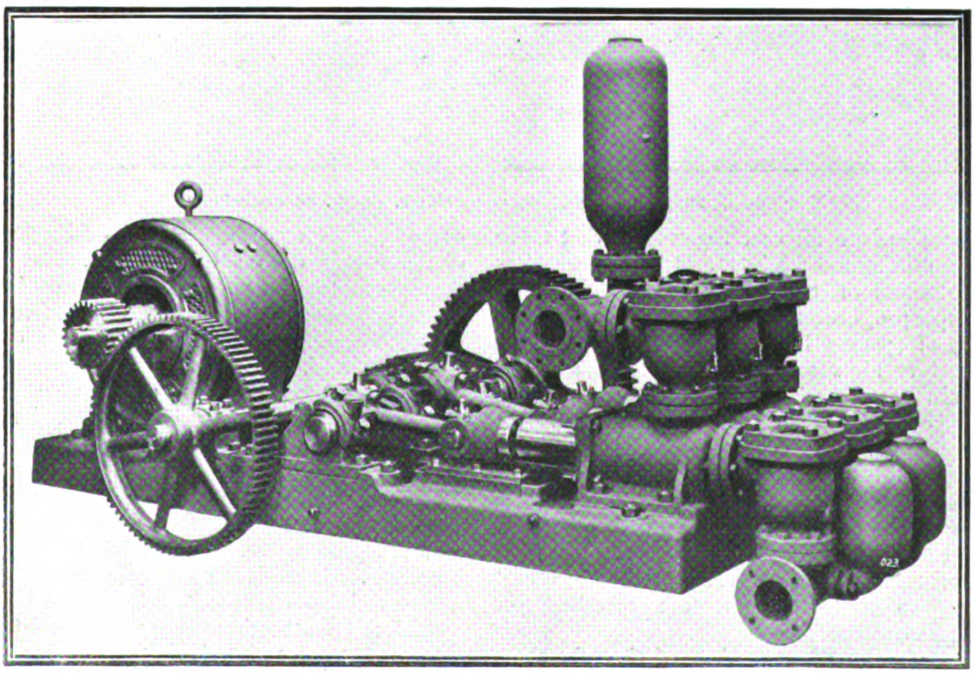


FIG. 1. PEARN HORIZONTAL, THREE-THROW, 6IN. BY 8IN. ELECTRIC PUMP.

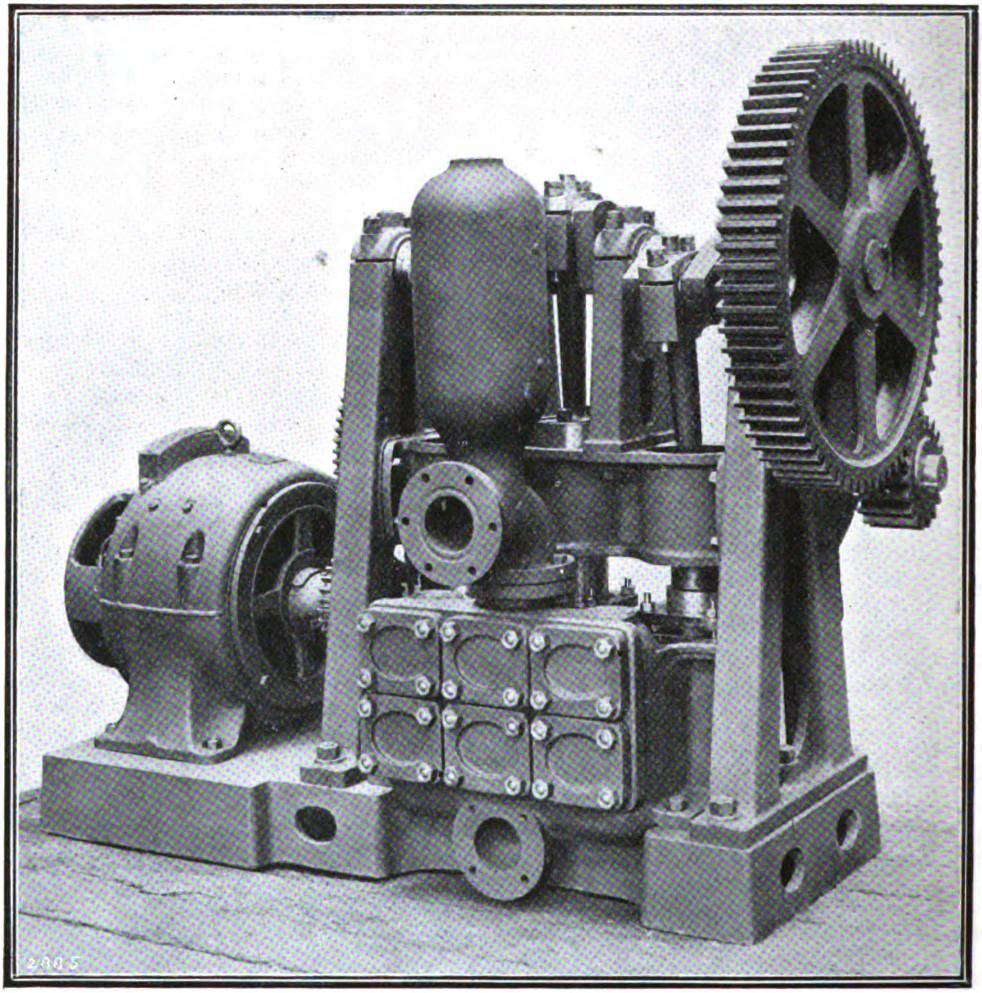


FIG. 2. PEARN VERTICAL, THREE-THROW, 6IN. BY 8IN. ELECTRIC PUMP

chambers are all cast together so that there is a minimum of joints, and each pump has embodied in it a suction vacuum vessel of ample proportions, thus effecting a great saving of space. In the single-ram pump the delivery air vessel is also embodied in the main casting. This line of power pumps ranges from 2in. diameter to 8in. diameter, with one, two, or three rams, and is thoroughly standardised, so that the production is on economical lines, and all parts are strictly interchangeable. For the purpose of exhibiting the several pumps in operation, two tanks, holding respectively 300 and 150 gallons of water, are installed for supplying the pumps.

The remaining portion of the plant exhibited consists of a Pearn patent high-speed surfacing, boring, milling, and drilling machine. It is driven by a 6½h.p. Electromotors motor running at 650r.p.m. The machine has a range of 24 speeds controlled by a speed-changing device of simple construction, and a range of eight automatic feeds, all instantaneously changeable and reversible, and applicable vertically, longitudinally, and transversely. The machine is built on absolutely original and novel lines, and is claimed to be a striking advancement upon any type of machine tool yet designed for performing the same functions. It is shown in action operating upon various castings, and attracts very considerable attention, every facility being extended to interested visitors to inspect and to test it.

Union Electric Exhibits.

Arc Lighting.

In the roof of the stand are fitted eight Excello arc lamps, four being on the direct-current circuit and four on the alternating-current circuit; the object being to prove that the alternating-current lamp is just as efficient and satisfactory for lighting purposes as the direct-current lamp. It is well known that the usual alternating-current arc lamp not only gives considerably less light, but is often very troublesome in operation. The Union Company claim that the operation of the alternating-current Excello arc lamp is even superior to the well-known direct-current lamp which has been so largely adopted for street, factory, shop, and warehouse lighting, notably in such places as Oxford Street, London; Lord Street, Southport; and the streets of Islington, Hornsey, High Barnet, Southwark, Stepney, Ilford, &c. The Excello arc lamp is shown burning yellow flame carbons and also white flame carbons, the object of the white flame carbons being to make the lamp suitable for the illumination of coloured goods. Hanging from the roof of the stand are seen two sets of arc lamps for colour-true, shadowless illumination such as is required in many factories and in practically all large shops and warehouses.

The inverted arc lamp evolved by the Union Company is one of the most efficient forms of lighting and gives a true production of the even diffusion of daylight. The addition of the economiser to this lamp has eliminated all flickering and fluctuation so often coupled with inverted arcs; owing to the source of light being entirely screened, the eye cannot possibly suffer from continuous application to the finest operations with this class of illumination. The other set of inverted arc lamps is arranged on the indirect lighting system, by which means part of the light passes upwards and part through an open reflecting bowl. This gives the advantage of casting absolutely no shadow either up or down, and, although not quite so efficient as the truly inverted lamp, has certain artistic advantages, and gives a decorative effect of having a more or less brilliant illumination distributed over the premises.

At the apex of each of the eight arches at the entrances to the stand are seen the Koh-i-noor arc lamps of the new type produced by the company, which give all the advantages of colour truth appertaining to open-type pure carbon arc lamps, and at the same time give long burning hours. Smaller sizes of the enclosed arc lamp have found a large field of application in shops and offices and banks of moderate heights and dimensions.

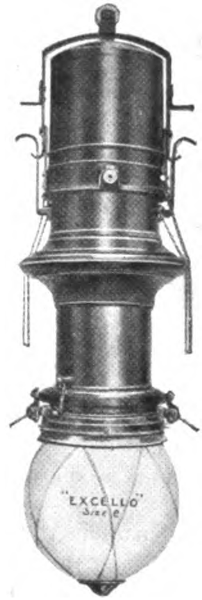


Fig. 1. The Excello Arc Lamp.

In the centre of the stand is seen a photographic arc of the kind usually used for printing process work and photographic and exposure work generally. There are also exhibited a selection of projectors suitable for theatrical work, or for application on smaller passenger and goods steamships.

In the small enclosed showrooms on the stand other types of arc lamps are shown, viz.: twin carbon enclosed arc lamps, ordinary enclosed arc lamps, specially enclosed arc lamps suitable for tramway and electric railway circuits, the Snowball Excello arc lamps, ordinary open-type arc lamps, and last, but not least, in such an important colour-printing neighbourhood as Manchester, the Coltru Daylight arc lamp, by means of which colour matching and colour printing can be carried on as well by artificial light as by daylight.

Electrical Instruments.

The range of electrical measuring instruments shown is very great; the Union

Electric Company are in a position to supply every class of instrument required for both technical and laboratory usage. A notable exhibit is the switch pillar head, carrying the new sector flange instrument as well as a double range frequency meter, the whole being fitted with illuminated dials, and suitable for the parallel coupling and regular control of A.C. polyphase generating machinery.

Other instruments exhibited are :—

- Portable ampere and volt meters, with single and double scales.
- Watertight ampere and volt meters.
- High-voltage voltmeters, reading up to 15,000 volts.
- Frequency meters on the Hartmann-Kempf principle.
- Electrical dynamometric ampere and volt meters.
- Electromagnetic ampere and volt meters.
- Switchboard apparatus.
- Moving-coil ampere and volt meters.
- Maximum and minimum signalling devices, including relays and visible signals.

The details and sizes of the above instruments are of course well known, and there is not much to specially remark in this connection, except that the instruments are finished in the usual style, the portable ones in closed-up polished walnut cases, and the switchboard patterns in either polished brass or iron cases, black finished with nickel relief.

The following, however, are special instruments :—

The 15amp. time meter is particularly suitable for purposes where current is charged by the time of consumption, such as, for instance, on arc lamp circuits, where the central supply authority may be charged an inclusive figure to represent the cost of current, consumption of carbons, and the necessary amount of trimming.

The tramway meters shown are largely in use on many tramway lines. Their object is to show the period of time that the current has been on the tramway car, as it is found by experience that the consumption of current on a tramway car is really proportionate to the time the current is on the car, and that there is a definite time period for almost every section of the track during which the current is really required, and all further amount of current consumed is wasted either in unnecessary acceleration or friction on the brakes. The use of these tramway meters, especially on circuits where the current is of considerable value, has been fully recognised. The indications are exceedingly simple, being merely readings of time, and not a series of dials and indicators.

A thermometrical electrical equipment of thermometers and instruments for indicating at a distant point the temperature of any one of these thermometers.

The electro-dynamometer is primarily for use in central stations and laboratory test rooms, &c., for standardising other instruments. All the measurements on this instrument are absolute, and not subject to change after period of time. It is a suitable apparatus for all modern equipments where accuracy of reading and closeness of guarantees have to be considered.

Other instruments include a suspension galvanometer with device for rendering the same ballistic when desired; measuring apparatus for insulation and capacity tests ; Wheatstone bridges for laboratory and cable-testing purposes, &c.

The exhibit of complete switchgear is a very comprehensive one as it deals both with high and low tension plant, as well as motor starting and controlling apparatus. The most important exhibits are the following :—

High-tension Motor Switchboard.

This consists of a three-pole oil-break switch, with overload and no-voltage release, interlocked with a rotor starter of the oil bath pattern, in such a way as to secure perfectly safe and reliable operation, and to eliminate all risks of personal shock as well as overload on the motor. The particular arrangement shown is entirely enclosed in metal framework, and is suitable for a 25h.p. 3000-volt motor. It is typical of the arrangements that would be adopted for motors having voltages as high as 10,000 volts. The same panel is provided with fusible cut-outs, and an arrangement for inserting a trip coil with a time element, if this is considered desirable. The board can be used either for overhead connections, or from a sealing box and underground supply. Particular care has been taken with the

design to have every part under good inspection and to ensure reliable working.

Alternating-current Distribution Panel.

This is a distribution panel such as would be used for an alternating-current circuit of moderate potential, and consisting of single-phase switches and fuses connected to a busbar, whilst mounted above are the following instruments:—

(*a*) Ammeter showing the total current passing.
(*b*) Voltmeter measuring the pressure across the busbars.
(*c*) Power-factor indicator.
(*d*) Indicating wattmeter, giving the correct energy loading on the circuit.
(*e*) Recording wattmeter.

The whole is mounted on marble panels ready for bolting to either an iron framework or other convenient support.

Direct-current Distribution Board.

This also is for circuits of moderate potential. It consists of single-phase switches and fuses feeding off busbars, and having in connection with each an ammeter and also a voltmeter connected up in a similar way to the alternating-current switchboard.

The two switchboards just described are used for controlling the circuits of the arc lamps and motors on the stand itself.

High-tension Switch Pillar.

This consists of a self-contained unit arranged for bringing the supply connection in at the bottom, and consists of a combined switch and fuse of the oil-break type, controlled by no-voltage and overload releases, having in circuit also an ammeter, and arranged with the time-limit control adjustable. Both the overload release and the time-limit control are adjustable outside the case, which is separated into three elements.

(*a*) The cover, which carries the ammeter and lifts clear away when desired, giving access to the mechanical working parts of the switches.

(*b*) The second element is also easily removable, consisting of the moving contacts and of the electrical elements of the switch, with the exception of the lower contacts, to which the incoming and outgoing cables are connected. These cables are accessible through doors at the front of the switch pillar.

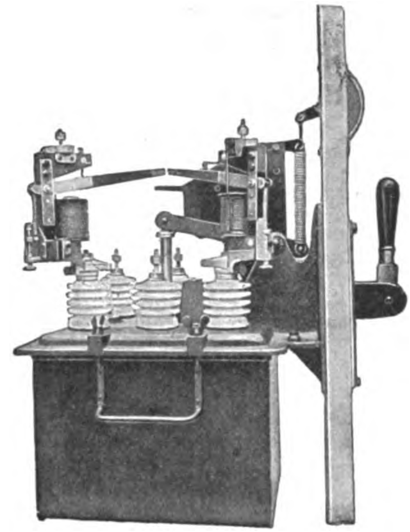


FIG. 2. THREE-POLE OIL-BREAK SWITCH WITH NO-VOLT AND OVERLOAD RELEASES.

The whole arrangement is very substantial, providing for perfectly simple and reliable control, with ample indicating apparatus, and gives easy access for inspection of the working parts and automatic features. Proper interlocking gear is provided so as to make it impossible to open the switch for inspection purposes unless the current is actually off.

Switches.

A triple-pole oil-break switch for 10,000 volts, 235amp., in which the release is effected by a rod running at the side of the switch, thus enabling the switches to be assembled in a simpler manner for switchboard work; and a triple-pole oil-break switch with a no-voltage release of a simple form directly coupled to the operating handle, are also shown.

Amongst the low-tension apparatus there is a good display of the pattern "C" lever switches, with brush-expanding contacts and locking levers, the range shown including switches up to 2000amp. capacity. One of the most striking low-tension exhibits is that of the marine-pattern switch, completely water-tight, tested under air pressure and ranging up to as large a capacity as 400amp., the whole switch being constructed so as to give quick break, working even for currents

as high as 250 volts pressure, and constructed of non-rusting material.

A complete range is also shown of smaller-size lever switches, from 40amp. to 250 amp., both for marine and general switchboard work.

Starters.

Amongst the starting gear are included various-sized controllers of the tramway or drum patterns, both for direct and alternating currents. These can be arranged with any desired method of connection, rendering them suitable for either tramway working, control of electric motor-cars, lifts, cranes, and large-sized motors. A range of motor starters is shown, both of the oil-cooled type and of the air-cooled type. The air-cooled type is interesting as being built entirely of non-combustible material on the unit system; each unit is surrounded by a brass radiating tube with insulators at the end, the insulators being held in a perforated framework and the connection made by means of bare wires direct from the unit to the contact stud of the starter panel.

The usual forms of release and control are shown, viz., no-volt release, overload release, slow-starting gear, and also handle devices enabling the overload release to act at the period of starting as well as after the motor has been at work.

An automatic starter for use in connection with filling tanks, &c., is shown in use directly coupled to an electric pumping set.

A large number of various forms of switch-fuses, and tubular fuses for voltages up to as high as 3000 volts, are also shown, as well as automatic cell regulating switches suitable for private installations of medium size, automatic voltage regulators for direct and alternating-current generators, and lightning arresters.

Paraffin-Electric Generator.

This set consists of a vertical engine designed to run at a high speed direct-coupled to a dynamo, and forms a light and convenient and exceedingly safe unit for the generation of electricity in private houses.

Since the introduction of low-voltage metal-filament lamps, enabling the number of storage cells to be reduced, a considerable demand has sprung up for small electric plant suitable for use in the smaller sizes of country houses, in which case small petrol motors have been used with the disadvantage of considerable fire risks. The paraffin motor obviates this risk, reduces very considerably the cost of working, and simplifies the attendance.

Motors.

The exhibit of motors to be found on the Union Electric Company's stand consists of both direct-current and polyphase machines. The largest exhibit of this class is a 440-volt 110h.p. motor arranged for running at about 150r.p.m. This machine is particularly interesting as being of the very latest type embodying the end shield and also fitted with reversing poles. The pole pieces are of laminated iron of special quality, securely bolted to the turned cast steel magnet ring, which is constructed at each end to hold the concentric end shields, one of which carries

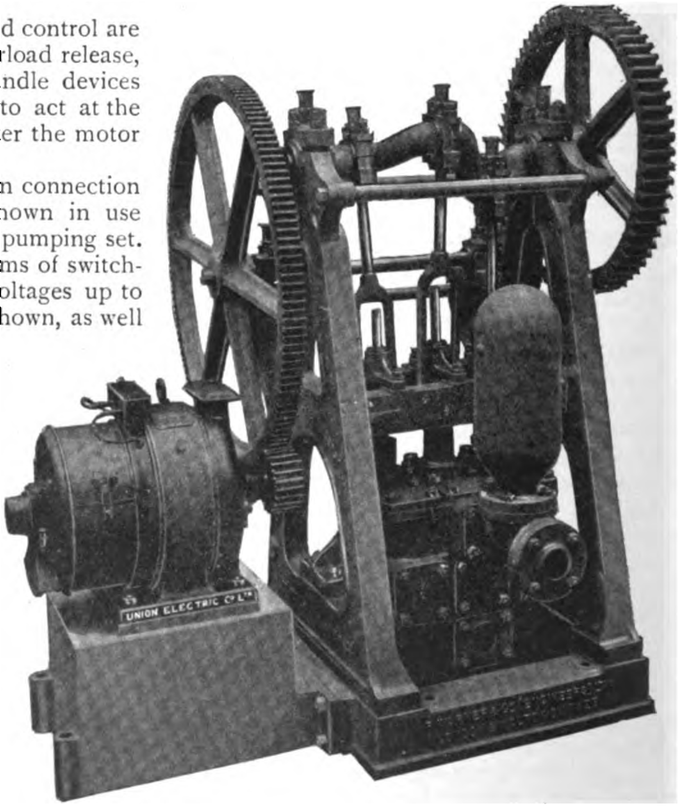


FIG. 3. UNION ELECTRIC-WARNER PUMPING SET

the pulley end bearing and the other the commutator end bearing and brush rocker.

The insulation of the commutator is of the compound system, including mica and also a supplementary insulator, which entirely obviates the well-known troubles with pure mica insulation.

Special attention has been paid to forced lubrication in the machines, thus reducing both the price and the weight to a minimum without affecting high efficiency.

Other machines on show consist of direct-current motors of the following outputs: 30h.p., 19h.p., 11h.p., 7h.p., $3\frac{1}{2}$h.p., $2\frac{1}{2}$h.p., and a number of machines of fractions of a h.p.

The larger machines, viz., from 32h.p. down to $2\frac{1}{2}$h.p., which may be considered as industrial machines, are of the end shield type, of the enclosed ventilated outfit, and are suitable for all factory and industrial uses, except in places where chemically charged atmosphere is present, or a very large amount of moisture. All the parts of these machines are strictly interchangeable, and are capable of carrying heavy overloads with low temperature rise, and suitable for placing in the hands of an ordinary consumer.

The smaller sized machines are suitable for automatic signs, winding apparatus, hand driving, &c., and are of the totally enclosed type and constructed to run for long periods without any attention whatsoever.

The three-phase machines exhibited are as follow: $11\frac{1}{2}$h.p., with slip rings, brush-raising gear, and short-circuiting device; $8\frac{1}{2}$h.p., with wound rotor and slip rings; $8\frac{1}{2}$h.p., with squirrel-cage rotor; 6h.p., with squirrel-cage rotor; $3\frac{1}{2}$h.p., with squirrel-cage rotor; $2\frac{1}{2}$h.p., with squirrel-cage rotor.

All the motors can be regarded as typical of the large range of standard dynamos and motors the company are in a position to supply either from stock or in a very short time. Connected to the motors are various Fortiter starters having no-voltage release only, others with combined no-voltage and overload; some with step-by-step starting gear, others with interlocked slow-motion gear; some with resistances air cooled, and others with resistances oil cooled.

Three-throw Pumping Set.

This exhibit consists of a triplex pressure pump, with 3in. diameter and 6in. stroke cylinders, three in number. The motor drive is through double-reduction gears, the set being mounted on combined bedplate; when the pump is running at about 50r.p m. it is capable of delivering 1375 gallons of water per hour.

The motor pump is shown in combination with an automatic tank-starter of the Fortiter design. The pump is constructed by Messrs. Robert Warner & Co., Ltd., of Walton-on-Naze, and the motor and starter are, of course, Union productions.

Centrifugal Pump.

A direct-coupled centrifugal pump, suitable for throwing 80 gallons of water per minute against a head of 80ft., is also exhibited.

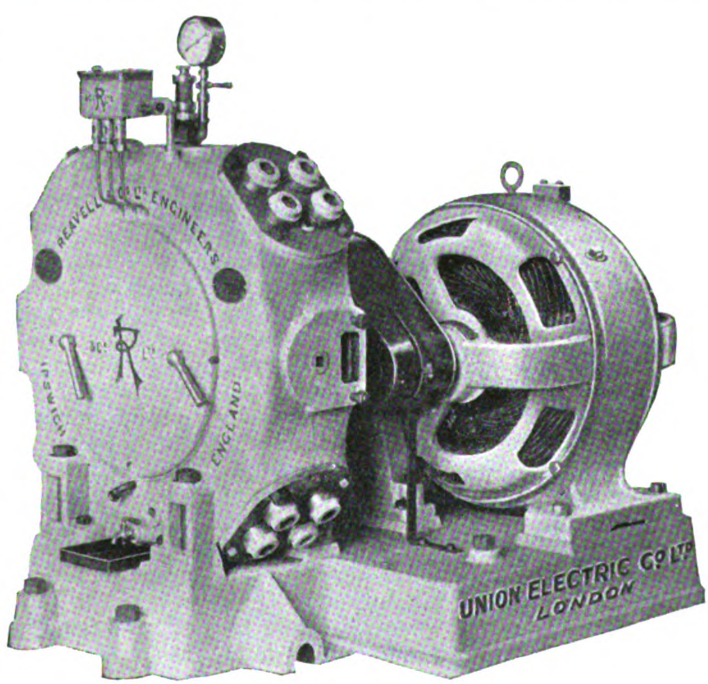


Fig. 4. Union Electric-Reavell Compressor Set

The pump is constructed by Messrs. W. Bracket & Co., Hythe Bridge Iron Works, Colchester, and is direct-coupled to a Union motor, the whole outfit being on one common combined bedplate. The motor is provided with a Fortiter speed regulator to vary the speed in accordance with the head to which the pump is required to force its water. For demonstration purposes water for this pump passes into a small tank.

Electric Air Compressor.

This set consists of a geared compressor with a capacity of 170 cubic ft., the compressor running at 250r.p.m., and being driven by a motor running at about 750r.p.m. For mining purposes air compressors of this class are readily mounted on wheels and made portable. The compressor is by Messrs. Reavell & Co., Ipswich, and the motor is of the Union enclosed ventilated pattern. This exhibit is shown on Messrs. Reavell & Co.'s stand.

Magnetting Machines.

THE use of magnets for the separation of iron particles from mixtures is not new, but it is not generally known that the designing and manufacture of such machines to handle various grades and classes of mixtures or material has become quite a specialised branch of engineering.

The Rapid Magnetting Machine Company, Ltd., of Birmingham, exhibit several types of their machines which merit description. The standard form of magnetic separator, Fig. 1, is suitable for treating brass, gunmetal, and copper borings and turnings, shoe rivets, buttons, &c. The material is fed into the shaking hopper, which, moving sideways, distributes it evenly and regularly across the whole width of the brass drum, inside which, radiating from the centre, are fixed the electro-magnets. The magnetic field extends round one-half of the drum. On coming in contact, the iron is seized by the magnets, and by means of ridges on the revolving drum is carried round to the back of the machine and out of the magnetic field, falling immediately by gravity. While revolving, the iron jumps and gambols from magnet to magnet, thus releasing every particle of non-magnetic material, producing

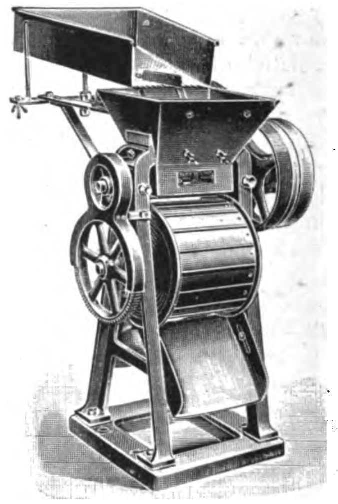


FIG. 1.

perfect separation and no waste. The non-magnetic material, being unaffected by the magnets, falls in front of the machine. Provided that the material is not too rough or curly, there is no need to first sieve the rough from the fine. This is a great advantage. The feeding hopper can be regulated to feed quickly or slowly as required by raising or lowering the back of the shoot. This separator has been very successful. Quite recently the makers received an order from the War Office, this being the second order for these machines from this source within the last nine months.

The type "A" (Figs. 2 and 3) electro-magnetic separator should appeal to all municipal corporations, having been designed for the purpose of removing iron from destructor furnace slag, the presence of which is objected to by those who use this material for making mortar, concrete slabs, bacteria beds, &c. Briefly described, the machine consists of an electro-magnetic revolving drum. The crushed clinker is fed in a regular stre m either by means of the shaker feed (shown in the illustration Fig. 3) or by other convenient means. The iron is immediately siezed by the electro-magnets and carried to the back, where it leaves the drum, falling into a suitable receptacle. The clinker, having no affinity for the electro-magnets, falls off in front as fast as it is fed on. It is said that as a rule the iron recovered shows a profit on the cost of treatment, and certainly the resultant clinker product commands a higher

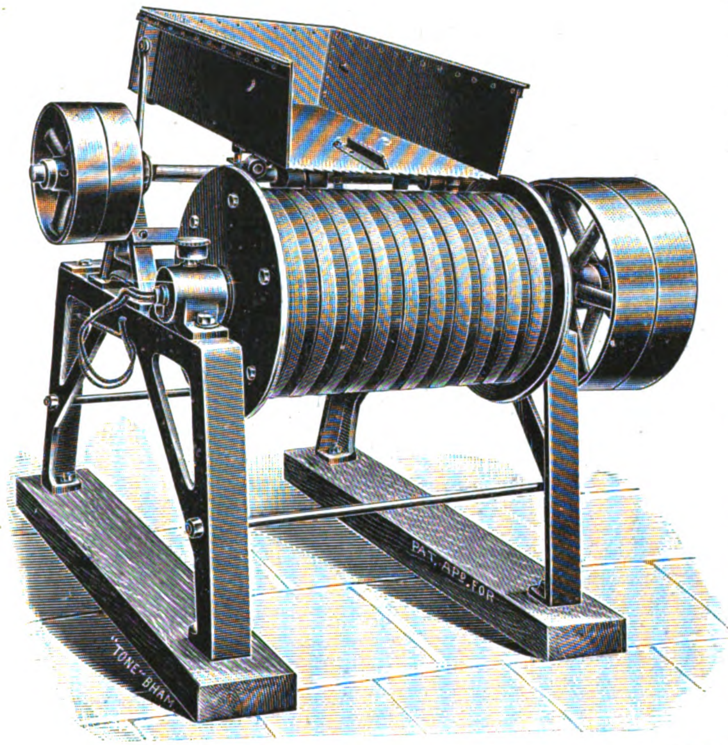


FIG. 2.

price. In any case, it is admitted that the removal of the iron would be a great advantage, as it would create a larger demand for the clinker so treated.

The type "B" electro-magnetic separator (Fig. 4) is designed for treating ground flint, potters' clay dust, calcined bones, &c. The two former materials, containing a very small percentage of fine iron, have hitherto been most difficult to treat, and, indeed, it is an open question whether it has been possible to treat it successfully up to the present time. This machine, lately introduced, is a new departure in that it has no revolving drum. For certain purposes the disadvantage of the revolving drum is that unless the iron is seized immediately it falls on to the drum, it is almost certain to ride over with the non-magnetic material, and fall among the same without separation. With this electro-magnetic separator the risk of iron escaping is practically non-existent. The apparatus consists of an inclined tray, provided with a reciprocating motion similar to that of a sieving machine. The shoot is built up of a series of powerful electro-magnets, each being separated from the next by brass of special section. The material is fed by suitable means at the top, and the oscillating motion carries it steadily and evenly down the shoot, the iron being arrested by the magnets. Attention is called to the fact that as each

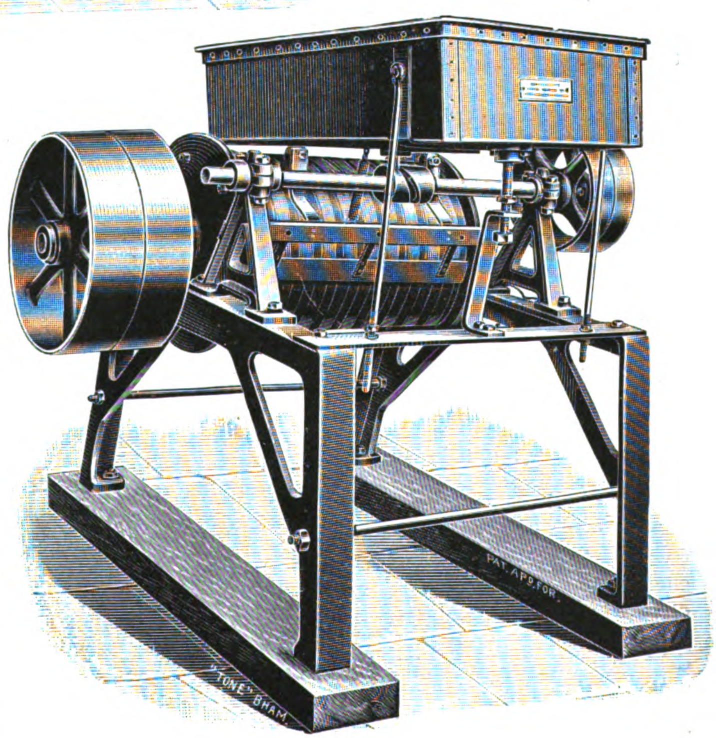


FIG. 3.

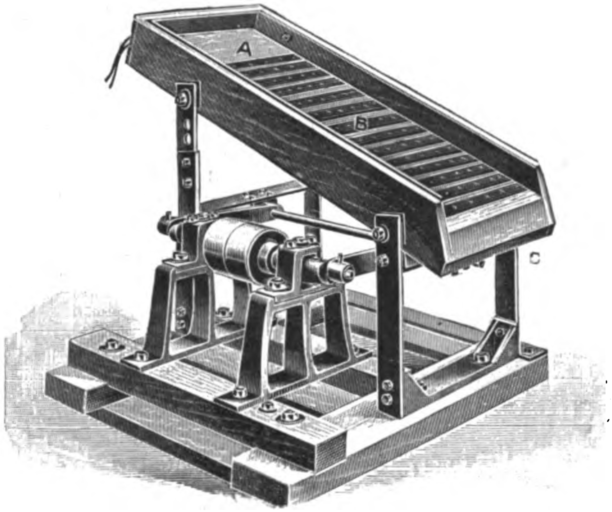


FIG. 4.

set of magnets extends over the width of the shoot, it forms, so to speak, a magnetic "hurdle" through which the iron must pass if it is to escape along with the treated material. It is apparent that, if the first magnet fails to secure the iron, the succeeding ones must each have a chance of retaining it. To clean the tray it is only necessary occasionally to stop the machine, switch off the current, and sweep off the iron, but in order to prevent the necessity of performing this operation too frequently, the brass section between the magnets is so arranged that it forms a pocket in which the iron accumulates at the one edge of the magnet.

When it is considered that the oscillations of the magnetic shoot amount to about 250 per minute, it will readily be admitted that with so much shaking and rolling about very little chance is given to the iron to escape the magnets. The efficiency, however, of this type of separator depends upon the number of magnets and the feed. The feed must not be excessive if results are to be satisfactory: a thin stream of material evenly spread over the surface of the tray is all that is required.

The "Rapid" electro-magnetic separator (type "C"), for dealing with liquid matter, such as potter's slip, glaze, and any liquid containing fine particles of iron, is similar in principle to the type "B" machine for dealing with dry material, but minus the reciprocating motion.

It consists of a trough which would be inserted to form part of the ordinary slip-trough, and is built up of a series of powerful electro-magnets, which extend across the whole width of the trough.

Each magnet is provided with a number of projections, serving the dual purpose of disturbing the flow, causing the liquid to have constant frictional contact with the magnets, and incidentally of arresting some iron. As distinct from all other systems which demand a slow flow, this requires a shallow, quick flow, so as to ensure constant frictional contact with the electro-magnets. To obtain this the rapid magnetic trough is given a fall of 4in. to 5in. to the foot, and whilst travelling over the magnets the liquid has the appearance of water running over the stony bed of a stream: this is the frictional contact.

A further and remarkable improvement is the collapsible bridge and alarm bell, which come into operation in the event of the electric current failing from any cause whatever. Should this happen, the bridge, which is held in position by electro-magnets, instantly collapses, diverting the flow of liquid, and preventing the iron accumulated on the magnets from flowing forward into the ark containing cleaned liquid. Simultaneously the alarm bell rings and continues to do so until attended to. This is a feature not possessed by any other system, and is of the utmost importance.

The general advantages of this system are as follow:—The electro-magnets are much more powerful than permanent ones, and are always at maximum strength, whereas the latter require to be re-magnetised frequently. Where the latter are used, owing to the fact that the slip flows between poles, the particles of iron do not necessarily pass near enough to be attracted by the magnets. With the "Rapid" system the iron must encounter the magnetic "walls," and provided the flow is not too deep (which is of primary importance) every particle of iron must get into the magnetic field and be arrested. Each permanent magnet must be cleaned separately, whereas the "Rapid" trough can be cleaned by one operation. The magnets are easily cleaned; for example, the flow may be stopped, the magnets washed down, and the work recommenced in less than five minutes. All

that is necessary is to stop the flow, switch off the current, and wash down the magnets.

Oriflamme Arc Lamps.

OLIVER ARC LAMP, LTD., exhibit the "Oriflamme" lamp, of which a large number are in use for street, railway, dock lighting, &c., in this country and abroad. The lamp is of British manufacture, and is said to be the only one of the magazine type in extensive use on the market. The magazines contain sufficient carbons to give the lamp a burning life of thirty-six to forty hours with each trim. Each magazine holds from six to nine pairs of carbons, and they are placed opposite one another, having a V formation. The magazine containing the negative carbons is fixed, and that containing the positive is pivoted at its top end, so that it can be swung away from the other for the purpose of striking the arc.

The movements of the striking magazine are controlled by the differential solenoids, the operation of the lamp being shown by the drawings Figs. 2, 3, 4, and 5. At one side of each magazine is a narrow slot, and working against the face of this is an endless chain of special construction passing over toothed wheels pivoted near the top and bottom of the magazine. The outside face of this chain carries at definite intervals a projecting roller which travels down the slot already referred to in the side of the magazine. In its path are placed the upper ends of the particular carbons which form the burning pair. Each magazine is provided with this carbon "conveyor," and the two chains are worked simultaneously from a toothed wheel of large diameter. The pawl engaging with this wheel is pulsated electrically by a small magnet in the upper portion of the lamp, and the circuit of this coil is closed by a special form of mercury switch which is rocked backwards and forwards by the controlling solenoids, and also by the armature of the small coil just referred to. The mercury is sealed in a glass tube from which the air has been exhausted, and two small electrodes which close the circuit of the racking coil are sealed into the tube, one on each end. The tilting of the tube causes the mercury to close the circuit, thereby giving a series of impulses to the pawl, and also to the carbon-conveying chains. This racking down of the carbons goes on at

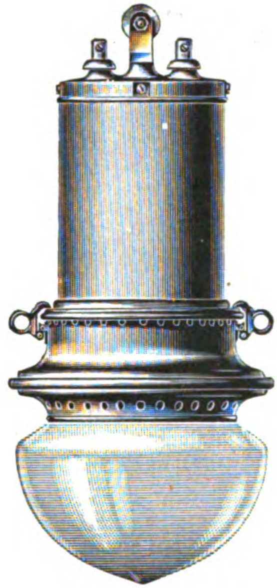


FIG. 1. THE ORIFLAMME ARC LAMP.

regular intervals, and when a pair is burned out the ends are discharged into the globe and a new pair immediately moved into position. The changing of the carbons occupies about twenty seconds, during which period, of course, the lamp is extinguished.

Particular attention has been paid to the ventilation of the globe and also of the lamp case. To ensure satisfactory burning the gases and vapours produced by the arc must be prevented from depositing on the globe interior, otherwise much light would be cut off during the later burning hours of the lamp. In the "Oriflamme" lamp there is a special chamber provided above the intensifier and between it and the mechanism, and in this space the dust and other deposits collect. A removable metal spinning of cone shape is provided to form the chamber, and as the bulk of the deposits settle on this they can be easily wiped off. The lamp interior is not sealed off from the arc gases, but these have no effect on the burning or the operation of the controlling mechanism.

All the parts of the lamps are made to gauge, and are therefore interchangeable. Knife edges are used for bearings, so that any clogging action of the deposits and dust are guarded against. The construction allows also of the easy removal of parts; for instance, either magazine may be removed by the withdrawal of two screws. The dashpot, which is the only part which

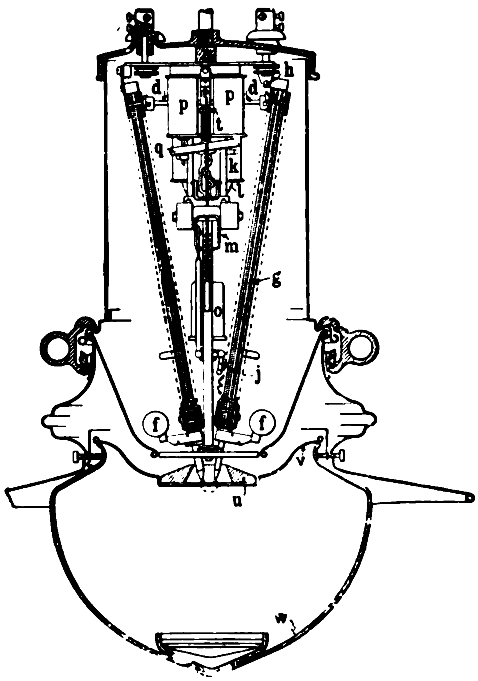


Fig. 2.

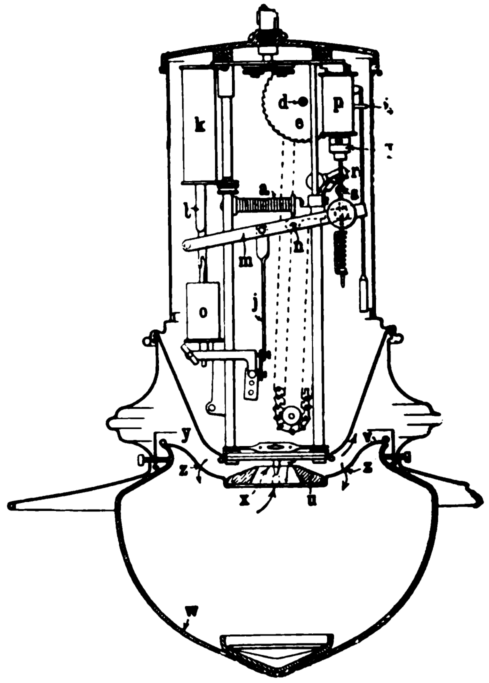


Fig. 4.

requires periodical attention, is provided with a bayonet socket for quick removal and replacement without taking off the case of the lamp.

The "Oriflamme" is made in three standard sizes for continuous current, viz., 7, 9, and 11 amperes, and as only 34 volts are required across the terminals, the power consumption is very low. For instance, five lamps may be burned in series on 200 volts, so that with 9 amperes (the usual size recommended for street and general lighting) the total wattage consumption per lamp, including all losses in line resistance, &c., is only 360 watts, or just over one-third of a unit per hour, giving 1200 mean hemispherical candle-power.

On alternating-current circuits it is usual to burn the lamps in single parallel, and these can be made to consume 220 actual watts only. The size generally recommended, however, is the 340 actual watts lamp.

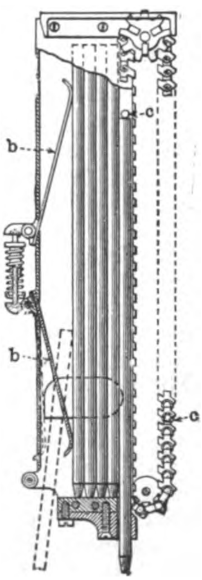


Fig. 3.

The cost of carbons in the "Oriflamme" lamp is claimed to be about 0.11d. per lamp hour, which is from one-third to one-sixth of that in other flame lamps.

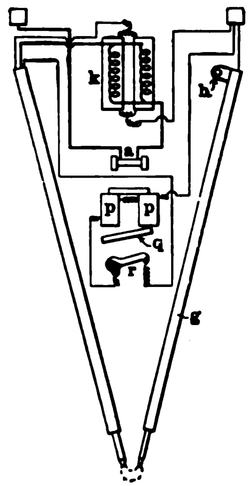


Fig. 5.

Amongst other users might be mentioned the following towns for street lighting :— London (City and West End), Aberdeen, Bedford, Bristol, Cape Town (S.A.), Croydon, Dundee, Exeter, Glasgow, Hastings, Maidenhead, Maidstone, Portsmouth, Willesden, Wishaw, and Woolwich ; for docks, lighting by the Admiralty at Devonport, Haulbowline, and Sheer-

ness. From the Admiralty there is an order in hand for lighting H M. dockyard at Hong Kong; also for railway lighting by the Caledonian, Great Northern, Great Western, London & North-Western, North British, and South-Eastern and Chatham Railways. There are also numbers in use for large works, car sheds, &c., in this country and abroad.

It should further be mentioned that there are twenty-eight "Oriflamme" lamps in use for the general illumination of the exhibition hall.

Renold Chains.

MESSRS. HANS RENOLD, LTD., limit their manufactures to a very full range of their well-known steel driving chains and the necessary sprockets, cutters for these, &c., and in their exhibit show the three main types of chains, viz., silent chains for high-speed driving, roller chains for medium speeds, block chains for slow speeds, carrying, &c.

A great range of sizes is shown as well as several drives complete with sprockets. Among the latter is a noteworthy example of the spring cushion sprocket supplied for service when the load is impulsive. The spring sprocket is arranged with part of the cover removed so as to show the construction.

There is also a silent chain shown running at about 1000ft. per minute, and it is interesting to watch, by means of the rotoscope, illustrated herewith, its action when in contact with the wheel teeth, and to see how the links and teeth pass in and out of mesh.

Renold silent chains are also to be seen in use on the stands of the following exhibitors: Messrs. Pollock & MacNab, Ltd., radial drilling machine; Messrs. George Richards & Co., Ltd., universal facing and boring machines and boring and turning mill; Messrs. Taylor, Garnett, Evans, & Co., Ltd., two-revolution printing machine. A leaflet is being distributed by Messrs. Renold showing two drives, each of which transmits 200h.p.—a proof that considerable powers can be satisfactorily transmitted by chains. A selection of photographs showing a few of the uses to which Renold chains are put forms an interesting feature of the display.

THE RENOLD ROTOSCOPE.

Industrial Electric Power Work.

THE exhibit of G. Harland Bowden and Company consists principally of special electric motors and operating gear. The firm makes a speciality of designing and erecting complete installations for the electrical driving of all classes of machinery for calico printing works, bleach works, iron works, collieries, ship and engineering yards, &c., and two special outfits are exhibited which merit special mention.

One is a 23b h.p. slow-speed motor, arranged for driving a reversing planer, and is shown in motion complete with the necessary automatic switch gear to secure reversal at the end of each stroke. It is specially designed for driving a 40ft. plate edge planer, which is capable of cutting three $\frac{1}{2}$in. steel plates, $\frac{1}{4}$in. cut, at a speed of 20ft. per minute, cutting with stationary tools on the forward and return strokes, the total weight of the moving table and plates being about 12 tons. The powerful magnetic brake, the pulley of which is attached to the motor shaft, automatically comes into operation directly the tappet switch is knocked over into the reverse position by an arm attached to the moving planer table. As the motor slows down and is almost at rest, the current is automatically reversed. This disengages the brake and starts the motor in the opposite direction almost instantaneously. The total time taken in the reversal of the whole of the gearing and table from full speed in one direction to full speed in the other is about five seconds.

The switchgear is such that adjustments can be made to increase or decrease the speed of reversal in accordance with requirements, provided that the demand for power is not in excess of the motor's capacity and that fluctuations of current are within that permissible on the generating plant. The motor is fitted with interpoles and is designed to give a very heavy starting torque.

The whole of the switchgear is enclosed in metal cases arranged to withstand the rough usage necessarily received under the conditions of such work.

Another motor is shown in motion coupled direct to a special triplex reducing gear. By means of this gear the motor speed of 1500r.p.m. is reduced to 75r.p.m. The reducing gear has an efficiency as high as 94 per cent. to 96 per cent. The high and low speed shafts are axially in line; a very compact drive is therefore secured. The motor and gear are coupled rigidly together on a combined cast-iron bedplate; the gear runs in oil in a cast-iron case. In conjunction with this outfit an automatic starter is shown in action which can be operated if necessary from a distance by means of a small single-pole switch.

A standard type of main switchboard is exhibited composed of three panels, one for controlling the generator, and the other two for controlling the external circuits. It is an example of the type of switchboard erected in many large works throughout the Kingdom, in many cases the boards being 30ft. long, and controlling many thousands of h.p.

A number of other different types of electric starting and controlling gears are exhibited, which are specially designed for works in which heavy handling is invariably met with.

The following types of gear are actually exhibited:—A 12h.p. 400-volt starting panel in metal case, complete with ammeter and including starter with magnetic blow-out and subsidiary carbon roller contacts, interlocked shunt regulator, and double-pole switch; a 5h.p. ironclad 400-volt starter with no-volt and overload releases; and a 30h.p. ironclad 400-volt starter with no-volt and overload releases, and with slow-action starting arrangement.

Many other types are standardised, amongst which might be mentioned a gear for controlling variable-speed motors which has been specially designed to secure a very gradual speed regulation on the motor. As an instance, it is possible by shunt regulation alone to vary the speed of the motor so that the machine may be run at any speed between 200r.p.m. and 1200r.p.m., there being no less than 500 points of speed between these limits. This particular type of gear is eminently suitable for paper-making machinery, and similar work requiring very fine regulation. Other ironclad gear is also shown, amongst which are power distribution boards and motor switches.

A model set of bevel gear with double helical machine-cut teeth is of interest; it can be turned by hand to demonstrate smooth and silent running entirely free from back lash.

A large number of photographs illustrate some of the work which has been carried out by this firm, and include a set of photographs of a complete generating station, designed and erected by them, which embodies all the latest features and up-to-date practice for economical running, and which is supplying current to nearly 200 motors. This is one of the many complete installations which have been erected by this firm of contractors.

Sunbeam Lamps.

AT this stand are displayed the specialities of the Sunbeam Lamp Company, Ltd., who are not only manufacturers of many types of electric lamps, but are also making and supplying everything electrical. The "Sunbeam" metal (tungsten) lamp is the latest development of the firm's products, and a full range of every description of this type of lamp is shown for circuits of 25 volts up to 250 volts, and of candle powers ranging from about 5c.p. up to 100c.p. It is claimed that these lamps have an efficiency of $1\frac{1}{4}$ watts per candle power direct burning on high volt circuits and also for series running. Special note should be made of the 25-volt lamp for house-lighting purposes, which is made in a comparatively small pear-shaped bulb, and exceptionally well adapted for artistic effects.

The illustration herewith, Fig. 1, shows one of the forms of this type of lamp, for which the company claim there is little risk of breakage in transit, owing to the form of filament which has been adopted in the manufacture of the lamp, and special attention is directed to the shortness of the bulb in comparison with other makes of lamp on the market.

The lamp is made under processes which are patented, and the filament is composed of "Wolfram," or what is commonly known in this country as "tungsten."

A full range of the well-known carbon

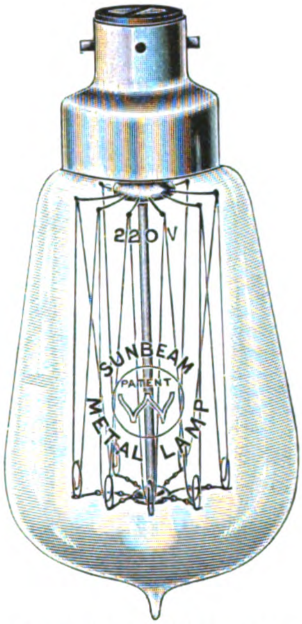


FIG. 1. SUNBEAM METAL LAMP.

FIG. 2. A SUNBEAM FITTING.

filament lamps of this company is also displayed. A new device in connection with this form of lamp is shown; it consists of an arrangement for reducing the light of the lamp to a very small unit, and thus enables the lamp to be used as a night light, or in places where a very dim light is required, but with ready access to turn the light to full power. Two filaments are fitted into one bulb and a light of 16c.p. can be given, or 1c.p. simply by pressing a switch.

The Sunbeam Company claim to have been the original manufacturers of the radiator, or heating lamp, and a number of these lamps are shown in radiators on the exhibit. A large range of the company's fancy carbon lamps for decorative purposes is shown, and also of coloured glass and varnished lamps for the same purpose. The company are specialising upon these, as, having their own glass works, they are able to match with promptitude any particular colour that may be desired.

There is also shown a full range of electrical accessories, switches, holders, ceiling roses, &c., supplied by the firm, together with an exhibit of Lundberg's specialities, in whose interests the company act as agents in the Lancashire district. A large and handsome selection of electric fittings is displayed; the illustration given above, Fig. 2, is an example of the many new designs which are being placed upon the market this season.

The Sunbeam Company are branching out into new paths, and for the first time are showing novelties in the way of electric-sign advertising. The signs exhibited would appear to be at once cheap and effective, and as such will doubtless be in considerable demand.

There are also shown various types of electrical measuring instruments, as well as the motormeter, by Elliott Bros., in whose interests the firm act as sole agents for the North of England.

Cables and flexible wires, dry batteries and Leclanché cells, and a full range of porcelain insulators of every description are also to be counted in the specialities shown by this company on their stand, and it is

worthy of note that the Leclanché jars are made at the company's own glass works in Gateshead, where also is manufactured the whole of the glass material used at their works in connection with their lamps.

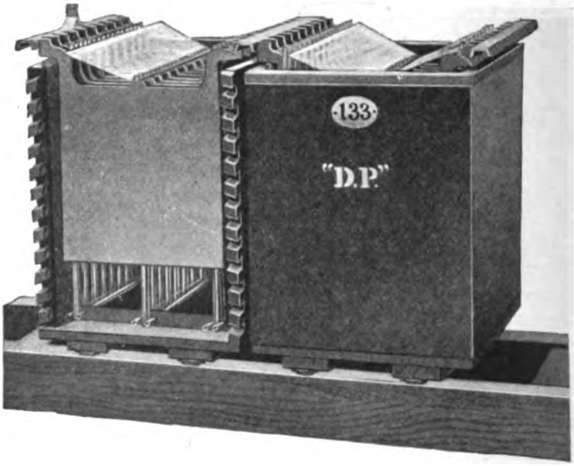


FIG. 2. D. P. BATTERY, TYPE L. S. H.

D.P. Batteries.

THE D.P. Battery Company, Ltd , exhibit a very large selection of accumulators, which are intended for various services. Of these, two forms are illustrated in Figs 1 and 2.

The former illustration represents the company's "L" type in glass boxes suitable for country houses, institutes, and the smaller classes of isolated electric plants subject to ordinary steady rates of charge and discharge. Fig. 2 illustrates the "L. S. H." type assembled in lead-lined wood boxes and suitable for large central stations or other heavy installations where higher and more erratic rates of charge and dis harge are called for by largely fluctuating power loads.

The positive plates used in all these batteries are of the Planté type, formed by the makers' own process, which produces, on the enormous superficial area obtained by the vertical ribbed formation, a tough adherent skin very different from the loose semi-adherent texture characteristic of some Planté formations. This hard closely-grained skin is claimed to be unaffected by the heaviest rates of charge or discharge.

The ribbed design of the plate with its horizontal binding ribs results in a mechanically rigid structure which is capable of expanding in any direction without buckling, whilst admitting of the free circulation of the electrolyte throughout the plate, and is said to give a more ample storage capacity than any other form of plate.

A recent development in these batteries is the new formation of the negative, to which has been given the title of the "D.P. Sponge" negative, and which has been designed to overcome the shrinkage and disintegration of the active material which was inseparable from the Faure type of plate. The active material now used is so constituted as to resemble a sponge in consistency—with a tendency to expand rather than to contract. The perforated screen which covers the face of the plate prevents the active material from falling away and at the same time allows the electrolyte free circulation and access to it.

Many other types of cells are exhibited on the stand, the several designs being calculated to meet practically every class of electrical installation. The complete batteries and specimen plates shown cover the entire range, from the small ignition battery plate of the motor car to the largest sizes of central-station cells up to those of 15,000 ampere-hours capacity.

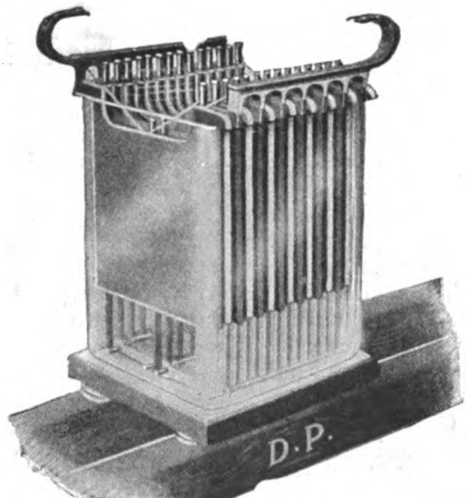


FIG. 1. D. P. BATTERY, TYPE L

Small Dynamo-Electric Machines.

THE Crypto Electrical Company occupy a position immediately to the right of the main entrance to the hall and have in evidence a very representative collection of their small dynamo-electric machines. The exhibits include a complete line of alternating-current motors from $\frac{1}{6}$h.p. to 16h.p. These machines are of the short-circuited squirrel-cage rotor type, and also of the slip-ring type. A full set of their continuous-current motors from $\frac{1}{6}$h.p. upwards are also shown. A speciality of the company is the manufacture of small alternating to continuous transformers, the smallest size of machines of this type exhibited having an output of 100 watts. This is of the combined type, the motor and the dynamo both being fitted in the same frame, and although mechanically they are practically one, electrically they are quite separate; the regulation of the output on the continuous-current side can be obtained without any alteration of the primary side, which, of course, is an advantage over the double-wound continuous rotary converter, in which machine it is impossible to obtain any regulation by means of a shunt field resistance. There are also exhibited examples of alternating to continuous motor generators, one of which is in use transforming the 400-volt three-phase to continuous current and lighting the Osram lamps which illuminate the stand. A further exhibit is a line of continuous-current rotary converters, which are particularly suitable for charging small accumulators in the most efficient possible way from high-voltage direct-current mains.

The Crypto Electrical Company was originally started for the manufacture of really small motors, but they have gradually dropped the manufacture of these miniature machines, which would rather come under the heading of toys, and as the market for small commercial machines developed they have designed a line of machines in sizes from $\frac{1}{6}$h.p. to 20h.p., which in mechanical construction and electrical efficiency will compare favourably with large machines. In designing these machines the Crypto Company have not lost sight of

FIG. 1. OLIVER WOOD GRINDER.

the fact that a large number of these machines pass into the hands of people who are totally unskilled.

Wood-Working Machines.

THE Oliver Machinery Company, Ltd., of Manchester, are showing a number of special wood-working tools, which will be found of considerable interest to engineers in connection with their pattern-shop equipments. One of the most important and novel machines is a wood grinder, which carries two 36in. discs, and is complete with piping, fan, exhaust pipes, and a dust-settling chamber. It will be noticed from the illustration above, Fig. 1, that this machine is driven by an electric motor from above the machine.

The Oliver universal dimension saw bench

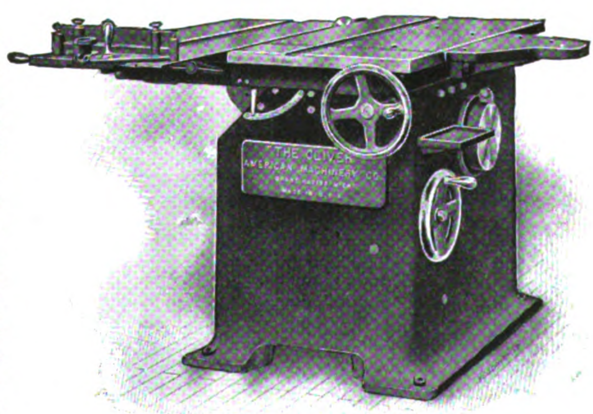


FIG. 2. OLIVER SAW BENCH.

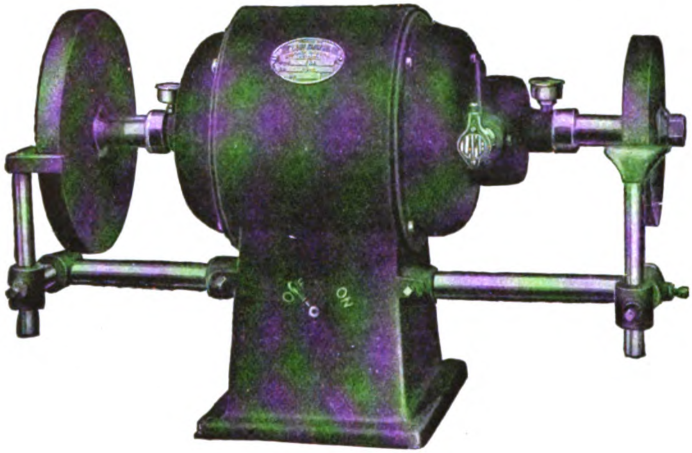


FIG. 3. OLIVER MOTOR-HEAD LATHE.

Oliver motor grinder is another of those electrical appliances which for convenience and general utility and compactness are rapidly superseding the older forms of tool. Other electrically driven machines shown on this stand include circular and band saw filing machines, besides circular and band saw setting apparatus.

is a machine well known in the trade on account of its universality and general handiness. The example exhibited is also driven by electric motor from the rear of the tool.

An example of the heaviest of the three types of band saws made by this firm is shown in operation driven by motor, and it shows itself to be a very fine tool in every way.

A unique machine is the Oliver motor head speed lathe, not the least of its interesting features being the extraordinary number of speeds which are possible on it. The

Portable Work-Bench.

THE particular specialities of the Union Standard Machine Company are a series of hand-power planers, shears, and punches, as well as the usual stocks and dies, &c., with which most engineers are well acquainted. The tool, or rather appliance, which merits particular attention here, is the "Pioneer" portable work-bench, of which Figs. 1 and 2, below, are illustrations. It will be seen that the bench is supplied either for general vice work or for pipe threading only.

That the "Pioneer" bench is an extremely valuable introduction is evident to any

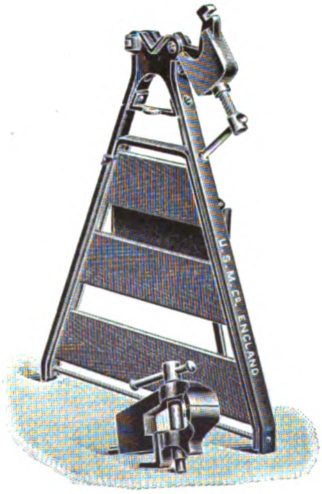


FIG. 1. THE PIONEER BENCH FOLDED FOR TRANSPORT.

FIG. 2. THE PIONEER BENCH EXTENDED FOR USE.

engineer who has been accustomed to outdoor work. Its two great features are—its portability, as it weighs only 45lb., or 80lb. with bench vice; its adaptability, as it can be used as a pipe vice or as a bench vice.

The bench vice has $3\frac{3}{4}$in. to 4in. jaws, and is forged of best materials. The pipe vice takes pipes up to 2in. diameter. The appliance is also supplied with bench vice or parallel vice only if required without the pipe vice. It will be seen that the bench is kept in an absolutely rigid position by the weight of the man who stands on the platform when using it. It should be added that the various types of the "Pioneer" benches are supplied at very low prices, and consequently they are certain to meet with a full and ready demand.

FIG. 1. THE THOMSON POCKET LAMP.

Pocket Lamps, Accumulators, &c.,

MESSRS. L. E. WILSON & Co., of Manchester exhibit a number of interesting electrical specialities for which they are agents. The Thomson Electric Pocket Lamp consists of an unspillable accumulator in a handsome nickel-plated case, and gives a useful and brilliant light for from five to six hours. This lamp has been designed essentially for pocket use and is fitted with a powerful lens reflector which intensifies the light, whilst the battery is a small 2 volt accumulator, which to all intents and purposes is dry, as very little trace of liquid is evident. The glow lamp fitted in the lamp is of the Osram metallic filament type, and the light emitted is of a strong white colour. There are a number of very useful accessories listed for use with the lamp for various purposes.

The Knowles patent porcelain lampholder is peculiarly adapted for use in situations where acid and alkali fumes exist, such as in chemical works, bleach works, accumulator rooms, saline atmospheres, &c. The holder is constructed of a single piece of porcelain without any joint, thus preventing access of any fumes to the interior.

One of the Laurie and Inglefield travelling lights is fitted on this stand. The arrangement consists of a suspended steel wire, on which runs flexible cord arranged in a series of loops which can be extended to any length as required. By the use of this arrangement great saving in current bills is effected, and the initial expense of electric light installations is greatly reduced. The whole apparatus is neatly arranged, and can be fixed in a few minutes. Other features of the exhibit are a stretching pendant which enables a light to be taken to practically every corner of the room, and the Nodon patent electric valve, which is an apparatus for transforming alternating into continuous current.

A particularly interesting exhibit is the Fors accumulator, which has been designed with a view to securing free circulation of the electrolyte, uniform action over the whole surface of the electrodes, and the ready

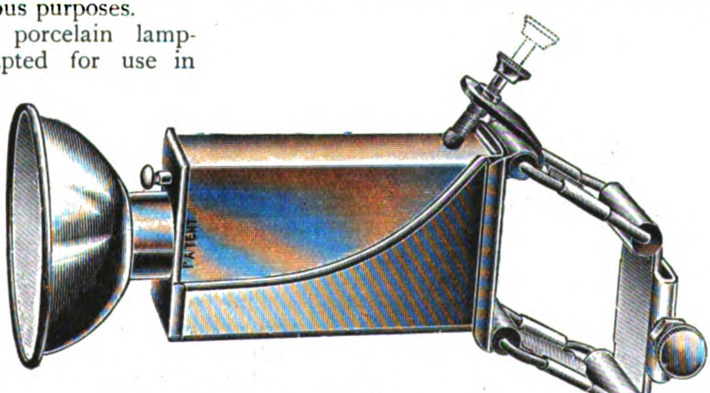


FIG. 2. THE THOMSON CYCLE LAMP.

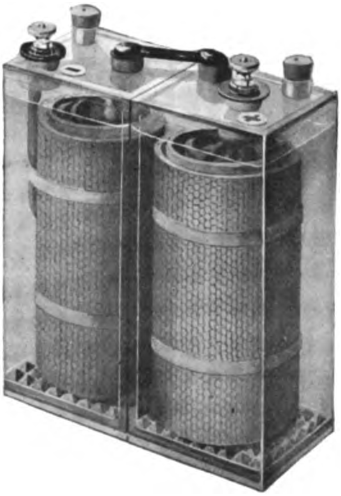


FIG. 3. THE FORS ACCUMULATOR.

escape of gases, together with very light weight, small size, high efficiency, and long life. The first object is attained by the provision of vertical channels between the electrodes and a porous septum which is interposed between the positive and negative elements. The second is attained by coating the whole surface of the lead supports with active material, which, following the form of the supports, assumes the channel shape above mentioned, at the same time enabling a much larger proportion of active material compared with the supports to be utilized, so that the cell has a large capacity per unit of weight, or a light weight for a given capacity—as much as 18 watt-hours per pound of complete cell being guaranteed. To hold the active material in place, and to prevent short circuits, the porous septum is employed; this is made of porcelaine d'amiante, an excellent insulator, and remarkably porous, so that it does not increase the resistance of the cell, and therefore does not introduce loss of efficiency. The construction of the cell is exceedingly simple; as usually made it consists of a positive electrode in the shape of a fluted cylinder, placed inside a porous pot, which is closely surrounded by the negative electrode. The whole forms one unit, any number of which can be combined to increase the capacity of a cell, and which can be made also of various lengths and diameters for the same purpose. The porous separator ensures absolute freedom from short circuit due to the accumulation of sediment at the bottom of the cell, so that the large space usually left on this account is not required and the volume of the cell is thus diminished. The electrodes being circular and the container square in plan, sufficient space for a store of electrolyte is found in the spaces left otherwise unoccupied in the corners. The ample support given by the circular shape to the electrodes enables very light grids for the active material to be used, and buckling is impossible. Local action is also prevented by the porous pot, there being no possibility of leakage between the plates, and the cell therefore retains its charge indefinitely when not in active use. The cell can also be charged and discharged at high rates without injury, an important advantage. The following are the distinct guaranteed advantages claimed for the Fors accumulator:—

Reduction of weight and space for increased output to exceptionally large surface area of active material being exposed, approximately 50 per cent; impossibility of short-circuiting owing to positive plate being absolutely separated by porous pot from negative plate, also, for the same reason, less liability of local action; impossibility of plates buckling, consequently can be charged and discharged at very high rates; capability of standing very rough treatment without liability of injury; retains its charge definitely when not in active use; guaranteed output, 18 watt-hours per 1lb. of complete cell; entirely British manufacture.

Gutta Gentzsch and Pernax.

THE exhibit of the New Gutta Percha Company, Ltd., consists of coils of wires and cables insulated with their special insulating materials known as Gutta Gentzsch and Pernax, which are suitable for wires for electric lighting, transmission of power, telegraph, telephone and bell services, and also for sheets of insulation.

Wires and cables insulated with Gutta Gentzsch and Pernax are not new, having been supplied by this company to many of the English railway companies during the past five years, and their requirements being so great (they practically take the whole of the company's output) that it has only recently been possible to approach the cable users generally.

Since customers have now had the full opportunity of using them under practical working conditions, the demand has been so great that it has become imperative to extend the manufacturing plant at the company's works in Greenwich. This additional plant is being erected as rapidly as possible, and the company will, within the next few weeks, be in a position to treble their output.

Gutta Gentzsch and Pernax are insulating materials of high grade, of which the sole manufacturing rights for the United Kingdom and the Colonies are held by the company. Neither of these materials contains any gutta percha whatever, but each consists of the finest quality Para rubber, to which is added a wax-like material, which is previously treated by a chemical process in order to give the mixtures the desired physical and mechanical characteristics.

As these insulations do not undergo vulcanisation, it is not necessary to use tinned wires, and for the same reason a tape under the braid is not needed, the braiding and preservative compound being an adequate protection under all ordinary conditions, the makers claiming that they expend the amount thus saved on adding to the quality of the insulation. If required, however, by an exacting client, tinned wires and tape under the braid can be supplied at a small extra cost. The dielectric is of the same radial thickness as adopted by the C.M.A. for their vulcanised rubber cables, and the insulation resistance compares favourably with that of vulcanised rubber, the prices, however, being considerably cheaper.

Wires and cables insulated with these materials are particularly adapted for electric lighting, tramway work, and bell, telephone, and telegraph purposes, and are so flexible that a seven-strand conductor can be bent backwards and forwards until every wire is broken, without damage to the insulation. They will also withstand, without deterioration, alternations of wet and dry, are not affected by atmospheric conditions or many of the acids, and are particularly suited for submarine work and other positions where salt is present.

As already stated, the first users of the cables were railway companies, who are still large buyers, and, in addition, they are now being used by most of the leading corporations and supply companies, many tramway companies, the National Telephone Company, and many large contractors.

Samples and prices, and expressions of opinion from customers who have been actual users for the past four or five years, can be obtained from the company or their agents, the local agents for Lancashire and Yorkshire being Messrs. Drennan, Glover, & Cooper, of Corn Exchange Buildings, Manchester.

Carbon Specialities.

THE well-known manufacturers of carbon brushes, contact pieces, who trade as *Le Carbone*, are showing a very fine collection of their specialities, including carbon brushes, carbon contacts, switch brakes, microphone discs, shot and powder, welding carbons, carbon dash-pot plungers for arc lamps, carbon brushes for trolley wheels, primary cells of different descriptions, and their patented connection for dynamo machine brushes fitted with pigtails. This firm claim to be the pioneers of carbon brushes in Europe, and exhibited them so long ago as the Crystal Palace Exhibition of 1892. Since that date they have gained many awards at exhibitions, their crowning glory being gained at the Paris Universal Exhibition of 1900, when they were placed *hors concours*, and elected to serve on the jury.

In addition to the "X," "Z," and "S" grade carbon brushes, they have during the last few years introduced several high conductivity descriptions, such as the "KK," "CCIV2," "LFC" (low-friction coefficient). It is claimed for the "KK" descriptions that they take a load of 100amp. to 120amp. per square inch of contact area; they are recommended for slip rings of alternating-current machines and induction motors, and for switch contacts which have to deal with a high-current density.

The "CCIV2" type can be loaded up to 125amp. to 150amp. per square inch, and is recommended for slip rings of alternating-current machines and induction motors, and also for low-voltage direct current machines designed for plating and electrolytic work.

The "LFC" and "LFC2" grades can take about 65amp. per square inch of contact area. Their main employment is for turbo-generators, or in fact for any description of high-speed machine. Their low-friction coefficient and noiseless running have been much appreciated by designers of

turbo-generators not only in England but also on the Continent, and it is claimed for them that they are the most satisfactory carbon brushes so far introduced for this exacting service.

There are several new descriptions of tram motor brushes to be seen, the chief claims made for which are their homogeneity and the splendid condition in which they keep the commutators on which they are employed, reducing the amount of attention necessary to a minimum. Special types of brushes are also shown for dealing with commutation difficulties, and these, which possess the property of attrition, are said to be entirely successful in dealing with insulating material of a hard and refractory nature.

Regarding primary cells exhibited, it is claimed that they are all modifications of the well-known Leclanché type, but that a special depolariser is employed which gives them a very large output and an extraordinarily long life. In addition to the merits of large output and constancy these cells have the advantage that the different constituents of them are interchangeable and easily renewed. Particular stress is laid on the advantage of the sealed forms for hot climates. The different types shown are the "Novator," "Equator," "Lacombe," "Carbi," "Z," "Voltex," "Pyrofer," "Steady," and porous carbon cell.

Ediswan Exhibits.

ONE of the most interesting stands in the hall is that of the Edison & Swan United Electric Company, Ltd. In addition to an extensive selection of the renowned "Royal Ediswan" and "Royal Ediswan Metfil" lamps (the latter being the name given to the new metallic filament lamp manufactured by the firm at their Ediswan Works, Ponders End, Middlesex) the stand contains examples of practically everything electrical, from the large illuminated sign down to the small pocket voltmeter for cell-testing purposes.

Commencing with the new "Ediswan Luxol" signs, a large example of these with the wording "Royal Ediswan Lamps" is fixed in a prominent position. A short description of this will be of interest.

The "Ediswan Luxol" is a most effective sign letter made of glass, in colour and appearance like snow ice, and equally visible by day or night. It has a full rounded surface with bevelled extremities, so that by daylight it reflects the light at every angle.

The under surface is hollow, and the curves are such that at night a single 5c.p. lamp is sufficient to illuminate thoroughly every portion of a 6in. letter, or two 5c.p. up to 12in. and three 5c.p. up to the 16in. letters, which is by far the greatest saving of current that has yet been introduced since illuminated letters have come into use. The rounded face of the letter only appearing above the surface, the sign may be read at a much greater angle than the ordinary facia or flush sign, or any front-illuminated letter. If required, the signs can be arranged to be worked by a motor-driven switch, *i.e.* for changing colours, blinking, or switching on letter by letter.

The Ediswan arc lamps, also manufactured by the firm, are shown in all types, from the yellow flame, burning with impregnated carbons, to the remarkable white flame pure daylight effect arc, burning with pure carbons and giving a spectrum exactly similar to daylight. This is the lamp by which all colours can be accurately matched, and consequently it is indispensable for drapers, silk merchants, milliners, and others where accurate rendering of colour is essential.

Ediswan fans are also largely in evidence, the types shown ranging from the standard type of table, trunnion, and bracket fans to the ordinary porthole and powerful box-bladed porthole patterns. A regulator suitable for use with the larger patterns is also shown.

The accessories section is strongly represented, and contractors may see here examples of all accessories used in general wiring work, as well as a number of patterns which are suitable for the largest installations. Amongst these will be seen the large knife switch type of cut-outs in iron cases, designed for use as main fuses on house or power circuit. The 25 and 50 ampere sizes are of the tubular type, the larger sizes being specially designed for heavy work.

To those interested in switch gear the stand will particularly appeal, as the firm are making a speciality of this class of work. Here is to be seen the Ediswan circuit breaker, which received such favourable notice from the technical Press on its introduction, and which at once took a high place in public favour. Also shown is the Ediswan improved pattern knife switch,

which is of a very high grade, of great mechanical strength, and which is claimed to be the best knife switch on the market at the present time. Specially noticeable is the small point switch, the "Phlatta," which is shown in both round and rectangular patterns. This switch has an extremely small projection, and being made on the Ediswan wedge system, under the firm's patents, is the very best switch obtainable for house wiring and general work. It is neat in appearance, and, on account of the small projection, can be used in places where the ordinary wedge tumbler switch would not be so suitable. Amongst the accessories are, of course, samples of every possible type of lamp-holder ceiling rose, cut-out, adaptors, flex couplers, and the like, finished in a style impossible to be obtained in cheap imported articles. It is hardly necessary to remind contractors that the "S" insulator type of holder was originally introduced and patented by the Edison & Swan United Electric Company, Ltd., to meet the demand for a high insulation lampholder for use on high voltage circuits.

For many years the Ediswan instruments made at Ponders End Works by the Edison & Swan Company have been known amongst instrument users as combining the highest degree of accuracy and finish with the lowest possible price. The Ediswan gravity type are made for continuous or alternating current, whilst the moving coil pattern are for continuous current only, and these high-class instruments are supplied in iron cases, black enamelled, with nickel-faced fronts. They are absolutely dead-beat and reliable to within one per cent., but if specially required with a greater degree of accuracy they can be supplied and guaranteed to within .2 of one per cent. at slightly extra cost.

In the "Ediswan" moving-coil instruments shunts are employed with absolutely no soldered joints. The volt terminals are also placed in such a position that no errors can possibly arise from the shunt, and therefore at any temperature the p.d. across the volt terminals is constant.

There are shown examples of illuminated dial voltmeters, vertical edgewise and horizontal edgewise volt- and am-meters, instruments with front and back connections, sector pattern instruments; and also shown is the celebrated Ediswan horse-power meter, calibrated to road directly in horse power, invaluable to all power users, showing as it does the output of any machine at a glance. There are also to be seen a large range of portable instruments, galvanometers, pocket voltmeters, and testing sets. Of course, there are many examples of fittings of all types and finishes, including a very complete range of ship and traction fittings, which compel attention.

General Electric Company's Exhibit.

THE General Electric Company's stand occupies one of the most imposing positions in the exhibition, and in many respects is novel and unique in design. It occupies a floor space of upwards of 1100 square feet. The exhibit is all open with the exception of an ornamental office, artistically decorated in white, purple and gold, and arranged in panels on which are fixed the various articles of their manufacture—telephones, measuring instruments, "Geekoduct" conduit, bells, &c.

All round the outside of the stand are arranged specimens of the latest types of street lighting fittings, from the lanterns of which the pure white rays of the high candle power Osram lamps throw a brilliant light on the whole of the stand and adjacent passages. Suspended from each street lamp pole, and carried all round the front and two sides of the stand, are festoons of "Pixielite" strip, bearing Osram lamps about 12in. apart. The whole of this "Pixielite" is painted white, and imitation smilax is artistically interwoven with it, making an extremely pretty effect. At each corner of the ornamental office four "Angold" magazine flame arc lamps are fixed, and on two other pillars on the stand specimens of the "Flamgold" arc lamps and open type band-break lamps, as well as the various types of arc lamps, enclosed and miniature patterns, are shown.

Generally speaking, the stand is devoted to each department of the General Electric Company's manufactures. A good display of the latest designs in electroliers and brackets is shown on the front part of the ornamental office; table and standard lamps are placed in prominent positions.

Great interest is being taken in the General Electric Company's insulated hand lamps. The new Osram candle lamp, which

is noted for its pure white light, is shown here and also in Goodall's model house exhibit next door. Wires and flexibles are also exhibited, and an elaborate panel has been prepared showing "Geekoduct" conduit and insulated fittings. A large panel is being devoted to showing various patterns of recording meters. One of the most interesting exhibits in the whole building is the General Electric Company's display of central battery and other telephones, switchboards and intercommunication telephones.

The accessories section of the General Electric Company's exhibit well confirms their claims in the recent and present advertising of the firm to the bold title of "Everything Electrical Made in England." Worthy of special mention are the oil switches and remote control switch apparatus.

Among the exhibits of heating and cooking appliances, a new form of radiator is displayed. This contains ordinary heating lamps inside cylinders, which promotes a free circulation of hot air. A great success is anticipated for this new type.

The yacht-type projector lamps on the top of the stand have naturally a very prominent position. The General Electric Company are making a special feature of these at present.

A special show-board of Osram lamps proves to visitors the advantages to be gained with these lamps over any other kind of lamp which will be put on the show-board for the sake of comparison. On the same board, all types of high voltage and low voltage lamps for angle and vertical burning are shown.

Over the front of the exhibit is suspended a large sign 12ft. long with the words "Osram Lamps" outlined with 25-volt 16c.p. Osram lamps, and in conjunction with this a transformer is at work. Owing to the practicability of the new G.E.C. engine dynamo lighting sets, the lighting of country houses, isolated hospitals, yachts, shooting-boxes, &c., with the 25-volt Osram lamp, 10c.p. and 16c.p., makes it worth the while of a landowner to instal his own plant, and where electric lighting in small houses is already installed the use of the transformer with Osram small voltage lamps has brought electric lighting within the reach of all.

The engineering side of the General Electric Company's manufactures is well represented, the principal exhibit being the 600kw. motor generator transforming from three-phase, 6600 volts, 50 periods on the motor side, to 500 volts D.C. on the generating side.

The chief feature about this combination is that both the D.C. armature and the A.C. rotor are mounted on one cast-iron spider, thus obviating a middle bearing; the shaft carrying the spider is running in two twin race-ball bearings, which makes a combination starting with a very small inrush current, and at the same time greatly increases the efficiency of these sets. The generators are fitted with slip-rings and are suitable for balancing 25 per cent. of the out-of-balance current in a three-wire system.

A number of these motor generators have been made for the Manchester Corporation. The approximate weight of the combination is 30 tons, the set being in actual use to convert the high-tension Manchester Corporation alternating-current supply to low-tension continuous current for the lighting and power required in the exhibition.

On the stand a motor generator set of especial interest is one of the three built at Witton for the new Osram Lamp Works, Hammersmith. The output is 100kw., 220 volts, 735r.p.m. on the D.C. side. Near it running is a motor generator set consisting of two of the smallest G.E.C. continuous-current machines, wound for charging motor car and other accumulators, and specially suitable for private and public garages.

Other important machines shown are an open multi-polar shunt-wound, slow-speed, type "Q" motor giving about 35h.p. at 200r.p.m. on a 100 volt supply.

A line of six semi-enclosed direct-current motors, starting at the smallest size, and illustrating the standard type which the company builds up to the largest sizes, all with ball bearings, when so required. Another range of six three-phase motors, starting from the smallest size, showing the type of alternating-current motors made by the General Electric Company up to 2000h.p. in twenty-seven standard sizes. Ball bearings are supplied if wanted.

There are also a special gas-tight coal-cutter motor and a gas-tight motor for work in fiery mines and places of a similar nature. The latter is manufactured up to the largest sizes by the General Electric Company, and is in use, for instance, in the largest factories of explosives at home and abroad.

Standard alternating and continuous current motor starters in semi-enclosed, water-

tight and gas-tight covers, are shown in considerable numbers; also special tramway type controllers for series regulation or series parallel working, for shunt, compound and series wound motors. The liquid starters and ordinary enclosed and gas-tight oil-cooled auto-transformers are in prominent position.

The starting of the Northrop loom, which is driven by a "Witton" motor, is the general signal for all visitors in the vicinity to congregate in front of it. Such is the intense interest of the Lancashire people in manufactures that all new appliances or applications of machinery immediately hold their attention. The point about the drive in this case is that the motor is specially hinged and its weight forms the tension on the belt, and compensates for any slip which may be caused through the motor having to attain full speed instantaneously.

NOTE.—Exigencies of time and space have precluded the mention in this number of many other noteworthy exhibits. There are several not included which are particularly worthy of extended notices. Such, for instance, are those of the Robertson Lamp Company, Ltd., the British Westinghouse Company, Ltd., Ferranti, Ltd., Marples, Leach & Co., Ltd., Babcock & Wilcox, Ltd., John Musgrave & Sons, Ltd., Browett, Lindley & Co., William Mycock & Co., James E. Lea, G. Brady & Co., &c.—to mention simply a few. Then there are many machine-tool firms, all of whose exhibits are well worthy of detailed treatment and which will accordingly be fully dealt with in our next number.

New Catalogues.

Alternating-current Meters.—FERRANTI, LTD., HOLLINWOOD. This firm have just published a new catalogue describing their well-known A. C. meters. This is a very creditable production, printed in three colours, with numerous line and half-tone illustrations, and well bound, so that it should be found useful for reference purposes for those who have contracts to place for this class of apparatus.

Seamless Tubing.—WM. GEIPEL & CO., LONDON, S.E., send catalogue of Benedict nickel seamless tubing. We understand that owing to improved methods of manufacture the colour of the tubing has been still further improved, so that it now has the appearance of best silver plating when polished. At the same time, owing to the fall in the cost of metals, the price has been reduced by about 20 per cent.

Reflectors.—SUN ELECTRICAL COMPANY, LTD., LONDON, W.C. Pamphlet No. 166 gives prices and illustrations of the "Adjusto" patent window fitting and metal reflectors for use with this. The illustrations show the various angles of adjustment secured by the use of this fitting, in addition to those obtained on the reflector.

Glass Shades.—SUN ELECTRICAL COMPANY, LTD. List No. 167 gives prices and illustrations of glass shades of various patterns for Osram and Tantalum metallic filament lamps.

Electrically-Driven Rolling Mill.—ELECTRICAL COMPANY, LTD., LONDON, W.C. Under the foregoing title this firm has just published a booklet giving a short description of a recently completed contract, the electrical equipment of Messrs. Dorman, Long & Co.'s rolling mills, Middlesbrough. The installation may be visited by those members who are interested in this kind of work on the occasion of the autumn meeting of the Iron and Steel Institute this year.

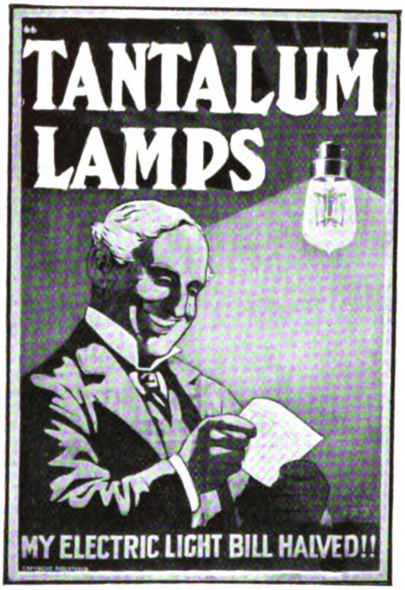
Photographic Arc Lamps.—ELECTRICAL COMPANY, LTD. List No. 288 illustrates and gives particulars and prices of arc lamps as designed for studio work, process engravers, engineers, architects, photographers, &c.

Ironclad Switches.—H. O. FARRELL & CO., MANCHESTER, send pamphlet giving particulars and prices of "H. O. F." ironclad switches, improved knife type, for pressures up to 500 volts.

Fuses.—I.T.E. ELECTRIC COMPANY (1907), LTD., LONDON, E.C., send us a pocket size circular giving prices of the "Shawmut" extended terminal lug type enclosed fuses, interchangeable on "A" type Shawmut, Noark, D & W, and other fuse terminals.

Fittings.—SIEMENS BROTHERS DYNAMO WORKS, LTD., LONDON, E.C. List No. 4a, III, I, gives illustrations and prices of "Solar" fittings for "Tantalum Sun" and spherical carbon-filament lamps. These fittings are suitable for private houses, churches, theatres, shop-window lighting, &c. An illustration of the five-light "Solar Corona" is given, this being specially designed for use with five "Tantalum Sun" lamps for the lighting of ballrooms, show-rooms, or churches. Two specimen methods of using "Solar" fittings for shop-window lighting are also shown in the list.

Continuous-current Motors, &c.—JOHNSON & PHILLIPS, LTD., CHARLTON. Leaflet A deals with continuous-current motors and starters, and gives prices for protected, ventilated, enclosed-type motors, either series, shunt or compound-wound for 110, 220, and 440 volts, and also prices for spare parts and armatures. Leaflet O deals with the various materials required by electrical contractors and engineers who have to handle cables in the course of their business. Both lists are coded to enable firms abroad to order goods by cable.



SIEMENS' NEW POSTER.

Copies of the leaflets may be obtained on application by those interested.

Arc Lamps.—JOHNSON & PHILLIPS, LTD, also send us copy of an open, enclosed, and flame arc lamp illustrated price list (Leaflet K).

Country House Lighting.—GENERAL ELECTRIC COMPANY, LTD., LONDON, E.C., send copy of Pamphlet P1232 on "Paraffin Engine Dynamo Sets," specially designed for country houses, shooting boxes, isolated hospitals, &c., for use with Osram metallic filament lamps. The whole plant is designed with the object of keeping the running costs as low as possible, so that electrical energy may be generated at a lower rate than charged by local supply companies for small consumptions. The manufacturers are willing at any time to send a qualified engineer, free of charge, to any part of the country to give advice in connection with installations contemplated, and for a small charge will undertake periodical inspections of all plant and apparatus to see that it is kept up to a state of the highest efficiency.

Electric Bells, &c.—GENERAL ELECTRIC COMPANY, LTD. Pamphlet L1258 gives prices of the G.E.C. electric bells, pushes, indicators, batteries, wires, cables, &c., at reduced prices. Leaflet S1268 deals with 200c.p., 300c.p., and 400c.p. Osram lamps. This is especially interesting owing to the fact that the new types are cheaper in first cost and cheaper to maintain than enclosed arc lamps. The leaflet is gummed on one side for inserting in the G.E.C. Osram Catalogue to face page 6. Two other new types, a 25-volt 10c.p. and 16c.p. Osram candle lamp, and a 25-volt 10c.p., 16.c.p. and 25c.p. Osram round bulb are also illustrated. A remarkable testimonial from a Glasgow customer testifies to the economy of Osram lamps.

Guide Attachments and Cradles for Arc Lamps.—UNION ELECTRIC COMPANY, LTD., London, S.E., send copy of list No. 1405, dealing with most important and difficult applications of outdoor arc lamps. The importance of suitable appliances for the class of work is considerable, and those illustrated in the pamphlet in question have proved in practical work in all climates entirely satisfactory.

"Union" Transformers.—UNION ELECTRIC COMPANY, LTD. List No. 1406 is a considerable enlargement of this firm's previous transformer list, and includes transformers suitable both for arc lamps and metallic-filament lamps for various frequencies, and having secondary ampere ratings, in the case of arc lamps up to 30amp. and in the case of metallic-filament lamps up to 80amp.

"Union" Accessories for Arc Lamps.—UNION ELECTRIC COMPANY, LTD. List No. 1404 deals with a selection of the most suitable devices for use in connection with the maintenance of arc lamps, hoisting gear, counter-balance weights, winches, &c. &c.

"Excello" Carbons.—UNION ELECTRIC COMPANY, LTD. List NE111 for the season 1908-9 gives prices of "Excello" carbons for use with this firm's well-known "Excello" arc lamps.

Trade Notices, &c.

"Tantalum" Lamps.—On this page will be seen a reproduction of a poster issued by MESSRS. SIEMENS, which we understand can be obtained in showcard form from Messrs. Siemens Brothers Dynamo Works, Ltd., 6, Bath Street, City Road, E.C. Messrs. Siemens have placed a large contract for bill posting in the provinces and for the display of similar smaller advertisements in the Underground Railway and Tube carriages in London.

Award.—THE UNION ELECTRIC COMPANY, LTD., have been awarded a medal of the first class at the Camborne Mining Exhibition for their exhibit of motors, arc lamps, mining switchgear, and measuring intruments. The Company have also received a letter from the President and Council of the Royal Cornwall Polytechnic Society expressing their appreciation of the illumination of the Exhibition, which contributed in a large measure towards its success.

Contracts Received.—MESSRS. JOHNSON & PHILLIPS, LTD., advise that they have secured an order from the Lochgelly Iron & Coal Company, Ltd., for underground switchgear for their Lochgelly pits, and from Messrs. James Dunlop & Co., Ltd., for the supply and erection of shaft cables.

The J. L. Manufacturing Company, Ltd., have purchased the business of the Johnson-Lundell Electric Traction Company, Ltd., together with the freehold factory at Southall, fully equipped with plant, machine tools, patterns, drawings, &c., and will now continue to manufacture under licence the patent "Johnson-Lundell" laminated field motors and dynamos, and will carry on a general electrical engineering business. The new company are now prepared to execute orders on the shortest notice.

The Electrical Magazine.

Vol. X. No. 5. LONDON. November 14th, 1908.

The World's Electric Progress.

Electro-Textiles.

The very complete article by Mr. Frank Nasmith, of which the second and concluding portion appears in this number, cannot fail to impress readers with the very great importance of the textile industry as a field for electrical development. As is indicated, there has already been a large amount of work done in providing electric power equipments for the numerous new mills which came into being during the recent years of the cotton boom, and also in the remodelling of existing steam-driven factories to accommodate the electric motor. From the descriptions and illustrations given it will be seen that the successful driving of textile machinery presented problems of a peculiar and unique character to the electrical power engineer, problems which he has so far solved as to ensure the confidence of the mill-owner in the superior merits of the electric drive.

It would seem, however, that there is still a great deal to be done in the closer linking up of the properties of electricity with the requirements of the manufacture and treatment of textile fabrics. In the way of power the suggestion is that future developments will take the course of simplifying the textile machines themselves. The electric motor is essentially a high-speed rotary machine capable of being built on commercial lines in the smallest of sizes. To bring such motors closer to, or even actually at, the spindles might be found feasible, thus doing away with the intricate and cumbersome mechanical parts of the present spinning mule or frame. Spinning machines and weaving looms are probably the most complex of all machines in general use to-day; whilst they are to a great extent necessarily so, owing to the number of simultaneous linked movements demanded for the working of the fibre to fabric, still, there is quite a large proportion of their array of mechanical parts accounted for by the fact that one constant-speed shaft and belt transmission formed the only source of power. It is time, now that electrical apparatus is available, with its automatic and precise control and ready subdivision and interconnections, to set about the entire re-designing of textile machinery. The textile machinist and the electrical engineer joining forces with this object are assured of an ultimate and great success.

A particularly striking example of this co-operation of textile and electrical experts is already in evidence. The Carver loom of which Mr. Nasmith gives particulars is so far an improvement that the perforated cards universally used for pattern-weaving are entirely done away with in this machine. The changes in the threads required to produce the pattern in the fabric are made automatically by means of an intermittent electric

circuit. The original of the pattern is in the form of a photographic reproduction on metal, the surface of which thus serves with a needle as a current-interrupting device, the printed portions breaking and the exposed metal surface making the contact. Then again there is the Arundel singeing machine, in which a peculiar form of electric heater is used in place of the usual Bunsen gas flame for the singeing of threads. The advantages of the steady, non-firing, electric heater for this service is obvious. Still another textile machine of which the electrical element forms an integral part is the Broadbent electric hydro-extractor.

Electriculture.

THIS term has been applied to the use of electricity as an aid in the cultivation of plants and vegetation, and it would appear, from the reports circulated at intervals from various sources, that in this there is offered an attractive field for research with every promise of distinctly beneficial results being achieved.

Sir Oliver Lodge, on the occasion of his opening a natural-history museum at Hanley, gave some interesting particulars of his work in this direction. In his case certain tests had been carried out over a period of three years, and on a larger scale than had before been attempted. Whilst, as the speaker indicated, the time spent so far on this work was altogether too short to allow of his stating the precise value of electricity as a means of cultivation, he was able to report that in the case of wheat the yield of grain under electriculture was found to be from thirty to forty per cent. higher than the same class of wheat on similar land and in the same season without electrical stimulation.

In the case of strawberry beds and tree-fruits also the speaker had secured greatly increased crops undoubtedly due to the effect of electrical application. As to the actual reason why electrification of the air in the neighbourhood of growing crops should have this remarkable effect for good, was to be the subject of continued experiment and research. Whilst it might be that the electrification took the place of sunshine, making an artificial and ideal summer, Sir Oliver Lodge said that at present i would appear to be due rather to some distinct stimulating effect which the electricity afforded to the plant.

Electrocution of Animals.

For more than a year past Dr. S. Leduc, of the Medical School of Nantes, has been engaged upon experiments connected with the possibilities of the use of electricity for the slaughtering of animals for food consumption. The results obtained are said to be in every way satisfactory, and such as to warrant the general practical adoption of a method which is at once humane, economical, and yielding a finer quality of meat than is got by the present systems of hand slaughter. It was during the course of his researches with a view to causing electric sleep, of which a full account appeared in THE ELECTRICAL MAGAZINE of last January, that Dr. Leduc discovered this new and rapid method of inflicting painless death. The apparatus necessary is simple and not very costly, and the current used does not require to be stronger than such as is general for lighting purposes of low voltage. This current, which is a direct one, is interrupted at frequent intervals per second, and these frequent interruptions are produced by a special apparatus designed by Dr. Leduc. If an animal be submitted to this current, the functions of life, circulation, respiration, &c., are stopped, and a perfect and general insensibility is produced, while none of the essential organs is injured. Should the current be stopped before two minutes have elapsed, life is restored again, and the animal does not appear to have suffered from the experiment. An animal subjected to this current for more than two minutes dies without pain from asphyxia.

The animal to be electrocuted is placed upon a platform insulated from the ground by glass or porcelain stands. One electrode is placed upon the forehead between the eyes, and the other is placed at the extremity of the spine, so as to concentrate the current through the brain and spinal marrow, the two places where the electrodes are applied having previously been shaved in order to secure a perfect contact. As soon as the current is established the animal falls senseless, and it is then bled. Owing to the great contraction of the muscles, the bleeding is very profuse, and consequently the meat is supposed to be of better quality.

ON PHOTOMETRIC STANDARDS.

J. K. HEYDON.

By definition a primary light standard is a source of light whose illuminating power is known — without a calibration against any other light—at the moment at which a photometrical comparison is made.

In order that the knowledge should be practically possible any proposed light standard must fulfil three conditions: (1) during actual use the light must be steady; (2) on each occasion of use it must be the same; (3) lamps made from the same specifications must give the same light.

Now the quantity of each kind of radiation from a heated plane surface—the quantity of energy of each different wave-length—depends upon three factors: (1) the size of the surface; (2) its emissivity; (3) its temperature. A light standard must therefore, in order to fulfil the above conditions, be constant and reproducible in respect of each of these three factors.

A lamp will have the best chance of fulfilling these requirements, in respect of the first factor, if its radiator is rigid and sufficiently large to render negligible the effects of wear and of the unavoidable irregularities of manufacture; of the second, if it is made of a pure metal which will not evaporate, tarnish, or undergo changes of structure on heating; and of the third, if the means of producing and maintaining the temperature are accurate, convenient, and easily controlled.

The question of temperature is the most difficult part of the problem, and several ways of regulating it have been suggested. One class of standards relies upon phenomena which automatically keep the temperature constant—for example, suitable chemical reactions taking place at a constant rate (flame standards), and changes of physical state—freezing (Violle's platinum standard), melting (Siemens' modification), and boiling (the Arc Standard and Violle's new silver standard). In another class the temperature is kept constant by regulating the source of heat so as to keep constant some quantity (which can be measured with suitable instruments) which depends on the temperature alone. Such quantities are the total radiation, the energy of some chosen wave-length, and the ratio of the energy at one part of the spectrum to that at another, or to the total, as in Lummer and Kurlbaum's platinum strip standard. All these quantities vary with the temperature alone as long as the size, shape, and emissivity of the radiator are constant. Finally the total radiation, and therefore the temperature, can be controlled by regulating the consumption of energy in the radiator; for all the energy supplied will appear as radiant energy provided losses by conduction and convection are prevented; this was the principle of the carbon filament standard suggested by the British Association in 1850.

For the benefit of those unfamiliar with the subject who may think that among these various methods a satisfactory standard must already have been found—which is not the case—it is worth while to indicate briefly the inherent imperfections of the chief types of standard hitherto suggested. Free flames, the simplest type, fail on the point which should be settled first—constancy of size. Enclosed, truncated, and screened flames are still unsatisfactory on account of the dependence of the emissivity and temperature on atmospheric conditions and flame height. Violle's standard, which employs a screen over solidifying platinum, is most inconvenient to use, besides being prohibi-

tively costly. Siemens' modification, in which a strip of platinum is heated till it melts, is cheaper but inferior, since the melting point is not truly constant. The Arc standard is useless because of the inconstancy of the position and size of the crater. So much for standards of the first class mentioned above.

Lummer and Kurlbaum's standard, in which a strip of platinum is heated till ten per cent. of its radiations pass through a certain screen, is probably the best, from a scientific point of view, yet suggested, but it requires too much skill for general use. In fact all standards of the second class are likely to fail on account of the difficulty of accurately measuring the auxiliary quantities.

Lastly the incandescent carbon filament has failed completely as a standard light on account of its lack of reproducibility in size, and still more in emissivity. Yet of all the possible methods of securing a constant temperature, that of regulating the input of energy to an electric lamp is the most hopeful because of the ease and precision of electrical measurements and the convenience of heating by electricity. It therefore seems a pity that it should have been abandoned after the one attempt alluded to above—especially as failure might have been anticipated in the circumstances. For a less promising radiator than a carbon filament it is difficult to imagine. Nor is any form of radiator which is heated *directly* by the electric current likely to be successful. If metallic, either it will be too thin to be constant and reproducible in size, or it will have too low a resistance for the input of energy to be accurately measured, whilst on the other hand carbon, electrolytic conductors, and filaments made of mixtures of conductors with non-conductors are all almost sure to give trouble on the score of reproducibility.

There remains however the resource, which nobody seems to have tried, of separating the device for heating from that for radiating the light. If that were done one could select the most convenient form of heater while still being free to study the requirements of the radiator.

The possibilities of a lamp made in this way are so great that the writer has been tempted to think it may fulfil the long-disappointed hopes of an incandescent light standard.

In a couple of experimental lamps now under construction the heater consists of a thin ribbon of platinum-iridium wound in a spiral groove upon a cylinder of magnesia and attached at each end to stout leads of the same material within the cylinder. This heater will be covered with a sheath of platinum sufficiently thick to equalise any irregular heating in the coil. The sheath has about twice the area of the coil, and it may be thought that the latter will have to be heated dangerously near its melting point before the lamp will give a good light. This objection, however, is partly removed by the fact that the heater, being enclosed within a white-hot shell, will radiate almost like a black body. Platinum black will be deposited on the sheath so as to give, after heating, a uniform dull surface which is not likely to change its emissivity much after prolonged heating, when the platinum will have evaporated slightly. The whole will finally be mounted in a vacuous glass bulb.

THE USE OF ELECTRICITY IN THE TEXTILE INDUSTRY.

FRANK NASMITH.

(Conclusion.)

In converting old mills to the electric drive the peculiar conditions of the buildings have to be taken into account and special installations designed to meet them. A very excellent example of adaptation is shown in the illustration Fig. 18. Messrs. Mather & Platt, Ltd., Manchester, who were responsible for the work which was the conversion of one of the Fine Spinners and Doubles Association's mills, have arranged the motor to occupy the position in the wall of the mill previously filled by a pair of bevel wheels, coupling the line shaft to the main upright driving shaft of the mills. The motor drives one of the floors of the mill, the motor spindle being extended at each end and fitted with flexible couplings. The motor is directly connected through these couplings to the line shaft, and drives in one direction the jack frame room, and in the other direction the mule room. The total power of the motor is 250h.p. and the full load speed 326r.p.m. The supply for the motor is obtained from the Manchester Corporation's three-phase mains, and the pressure at the terminals of the motor is 400 volts, and the frequency 50 cycles per second. As is probably well known, Messrs. Mather & Platt, Ltd., are makers of a wide range of machines quite apart from electrical machinery. Their textile side is considerable, and they are large makers of machines employed in bleaching, dyeing, printing, and finishing fabrics. Naturally their knowledge of driving these machines is extensive, and in certain cases they have adopted the electric drive, as is particularly well exemplified in Figs. 19 and 21. Fig. 19 shows a large calico-printing machine. The machine itself is known as a 12 nip "Saree" printing machine, and is driven by a 35b.h.p. motor running at a speed of 280r.p.m. off a 205-volt circuit. This is a very striking case where the individual drive is the best. The large power necessary, and the fact that these machines are very often stopped, make such a form of drive most economical. The other illustration—namely, Fig. 21—shows a finishing calender driven by a 22½h.p. motor at 250 volts, 200-1000r.p.m. It will be noticed that the motor is geared direct to the machine.

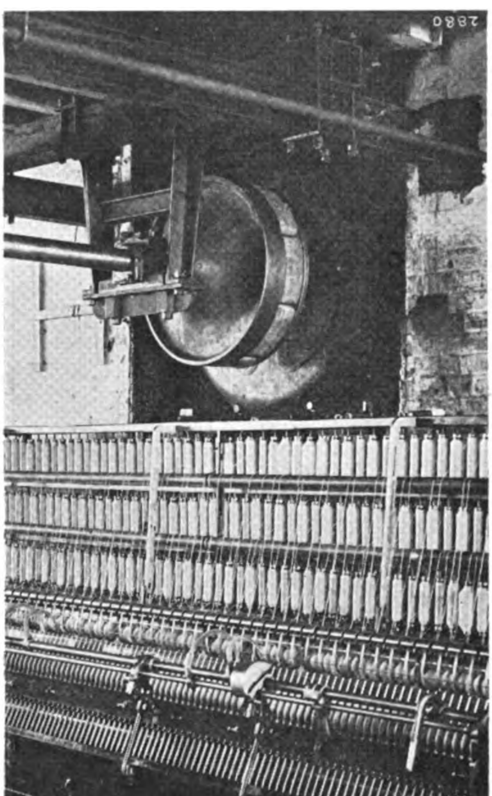


Fig. 18. Employment of Available Space for Motor.

The fire appliances of textile mills have been brought to a high state of perfection, and it is only in accord with the progress being made that electricity should enter into the field of useful adjuncts. In Fig. 20 a motor direct-coupled to a high-lift fire pump is shown. These fire pumps are

constructed on the centrifugal principle and give a high efficiency.

Although Messrs. Siemens Bros., Ltd., of London, deal with all classes of drive, their arrangement for looms will probably be the most striking illustration of their energy we can bring before our readers In dealing with loom drives, Messrs. Siemens appear to have expended considerable thought upon the nature of the particular drive, and as a result have produced a system which is admirably adapted for the purpose. They express the opinion that in the case of looms, individual driving is especially advantageous, and give as their reasons the increased output possible and the better quality of the fabric produced. In view of the argument that individual driving, especially for small looms, is uneconomical, Messrs. Siemens bring

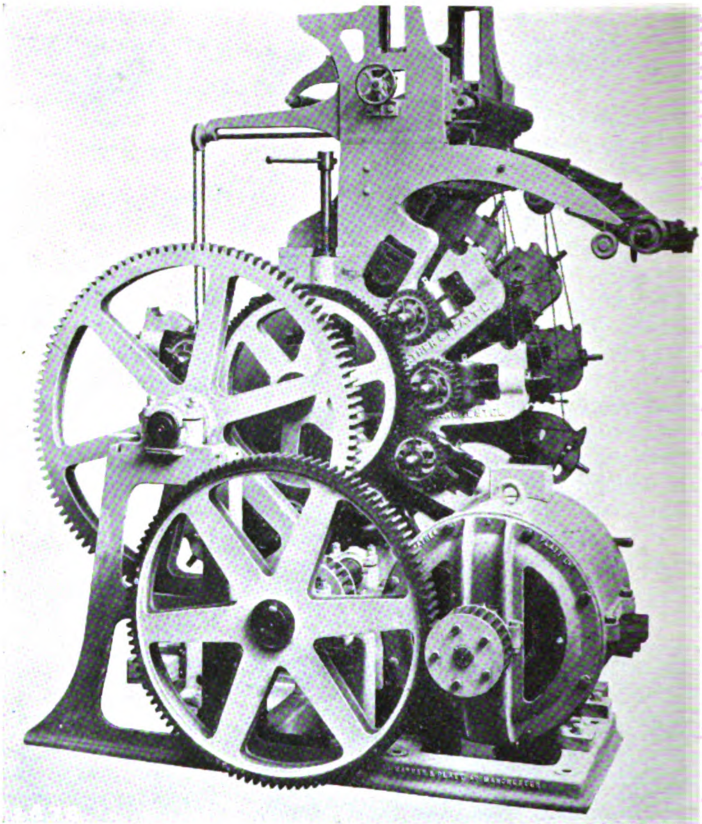


Fig. 19. Large Calico-printing Machine, Electrically-driven.

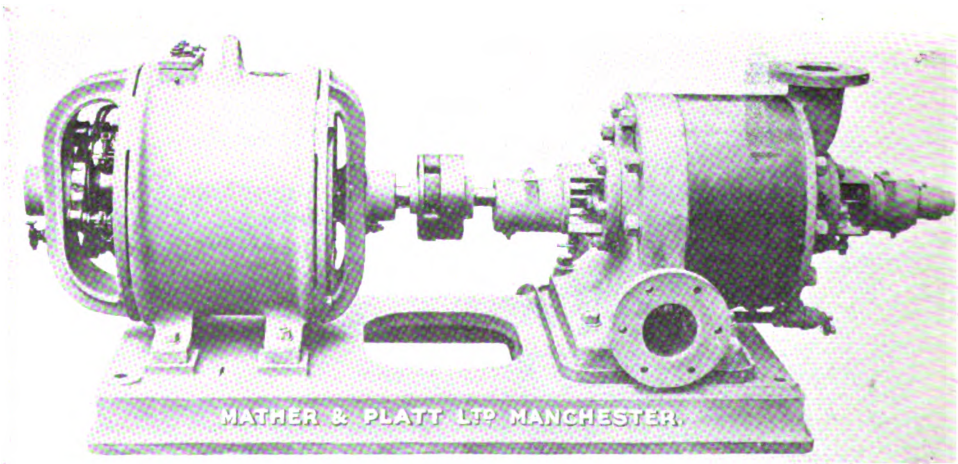


Fig. 20. Direct-coupled Motor and High-lift Fire Pump.

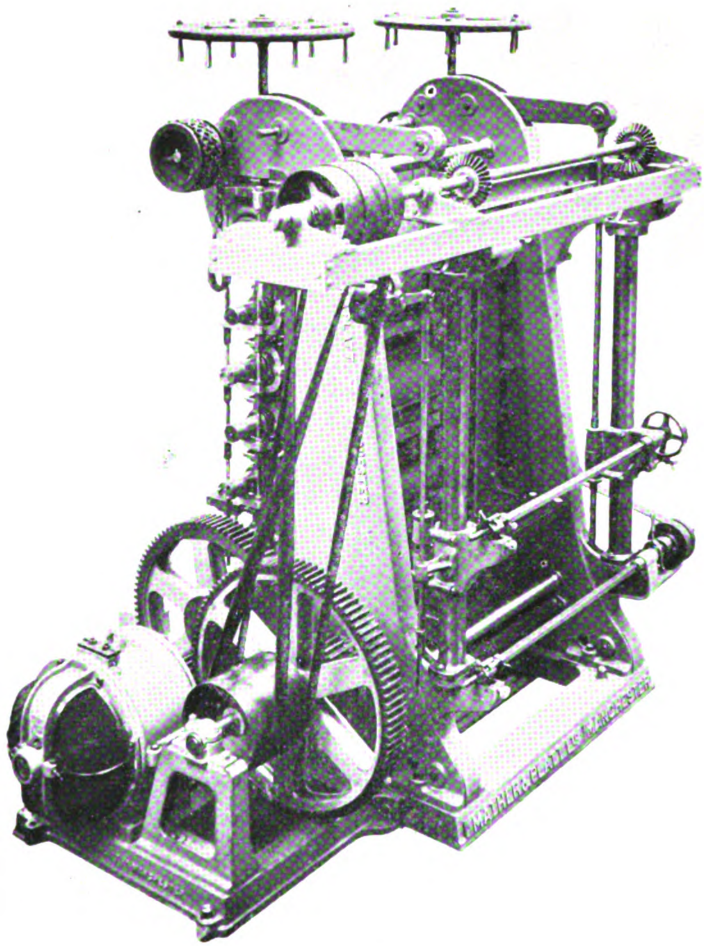


Fig. 21. Direct-driven Finishing Calender.

forward the argument that it often happens that looms are standing, and, further than this, the shafting and belting of a grouped drive absorb a very large amount of power with that required for the looms themselves. While agreeing with the latter portion of this statement, we do not quite agree with the earlier portion. In weaving plain goods it is absolutely necessary that the weaver should keep the whole of her looms running constantly, and she should waste little time in piecing broken warp threads or inserting a fresh cop within the shuttle. We can quite agree with the plea for individual driving, however, in the case of heavy looms; for instance, such a loom as is shown in Fig. 22. In carrying out an installation, Messrs. Siemens employ a three-phase motor with short-circuited rotors, designed to give a large torque at starting. These have been found to be perfectly satisfactory, and Messrs. Siemens have standardised a special line of motors for this class of work, there being eight sizes, ranging from 0.2h.p. to 2.0h.p. Three standard driving arrangements have been developed by this company. The first arrangement is a short belt drive with a spring belt tightener; the second is a gear drive with a friction coupling which can be set to slip when an abnormal torque occurs. This arrangement is shown in Fig. 23. The third arrangement (shown in Figs. 24 and 25) is also a gear drive with a friction coupling set to slip, but with the addition of a centrifugal arrangement so designed that the loom shaft does not begin to rotate until the motor has nearly obtained full speed.

Of course it will depend upon the requirements of each particular case which of these drives will be utilised. The first is the cheapest and is generally applied to small looms working on cheap classes of fabric.

In the illustration marked Fig. 26, the second method is shown applied to heavy woollen looms. Messrs. Siemens have paid particular attention to the question of wiring, which is of extreme importance to textile mills. In the case of a weaving shed the looms are connected in groups of four, two wide and two deep, and the motors placed at the adjacent corners of the four looms, and at each group

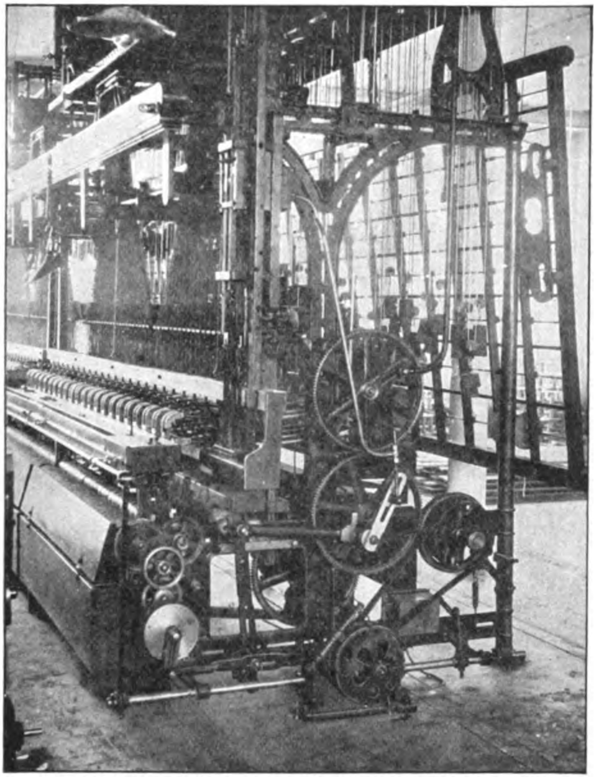


FIG. 22. DIRECT-DRIVEN RIBBON LOOM.

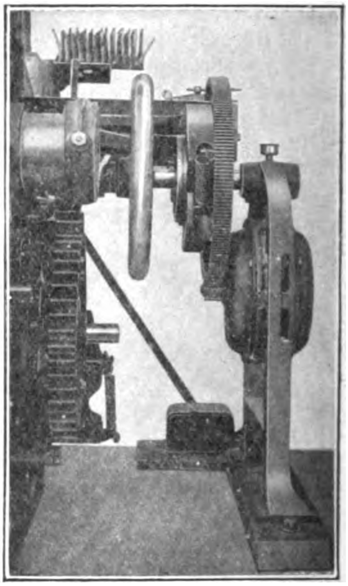


FIG. 24. SPECIAL FORM OF GEAR DRIVE FOR LOOMS.

of four looms a shallow distributing box containing twelve fuses is let into the floor. This box has a strong cover plate hinged and locked, and is flush with the floor. It is only necessary to run a

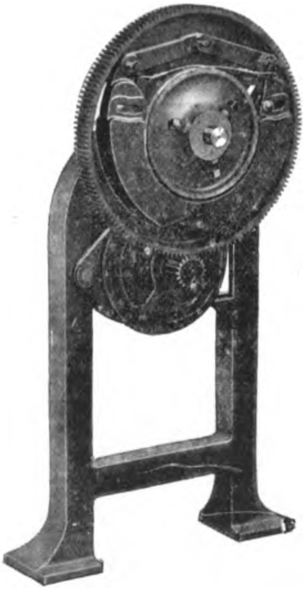


FIG. 23. GEAR DRIVE WITH FRICTIONAL COUPLING FOR LOOM.

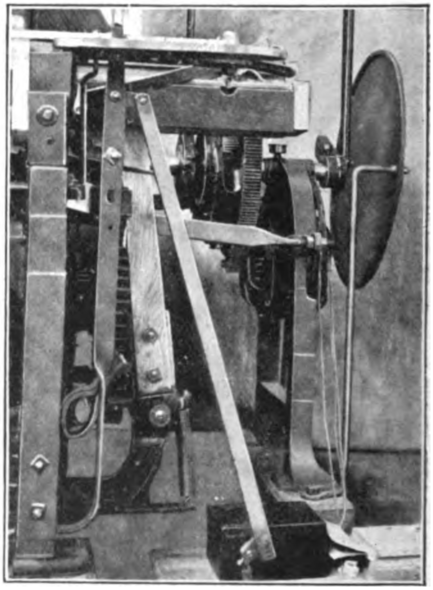


FIG. 25. SPECIAL FORM OF GEAR DRIVE FOR LOOMS.

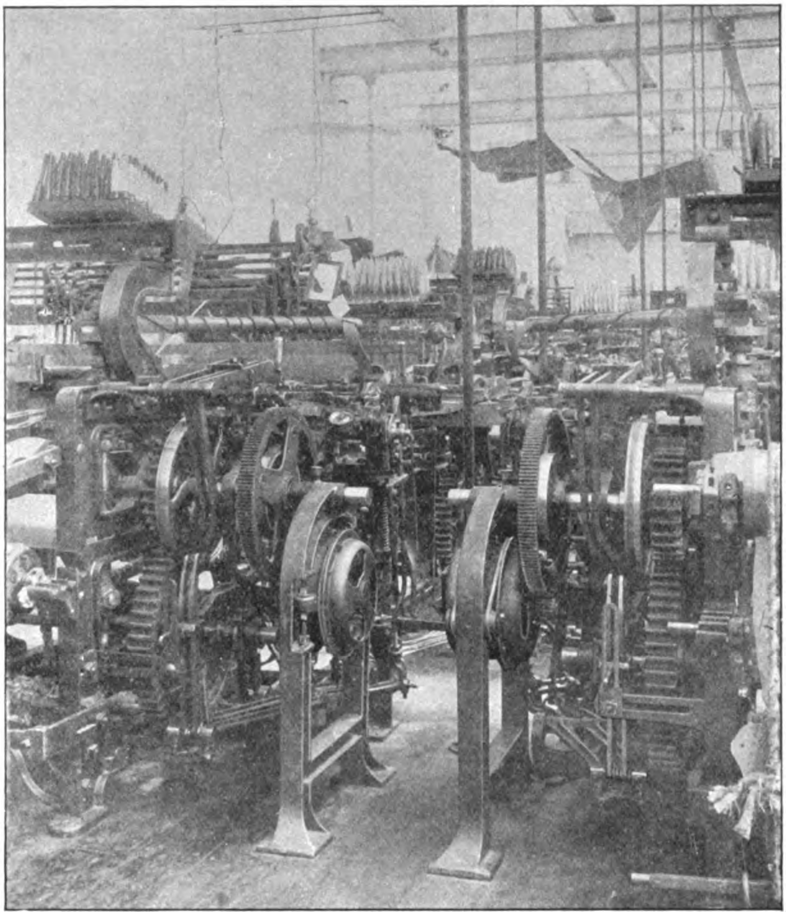


FIG. 26. METHOD OF DRIVING HEAVY LOOMS.

2ft. or 3ft. length of wiring from the box to each of the four motor switches, which in turn are placed close to their respective motors.

It has been pointed out already that in certain cases individual driving is of extreme value, and such machines as are found in bleaching, dyeing, and finishing works should always be driven in this manner, as it is necessary to run them intermittently. In spinning and weaving mills, where the whole of the machines run from 6 o'clock each day until 5.30, with only the half-hour and hour stop for breakfast and dinner, individual driving is not so necessary, but in the class of trade to which we referred it will often be found that several of the machines are stopped for a whole day at a time, others in the same department being at work.

In respect to this application of electric power the illustrations of the installation carried out by Messrs. Drake & Gorham at the works of Messrs. Porritt Bros. & Austin, Stubbins, near Ramsbottom, are of extreme interest. The department, which has recently been equipped, is concerned with the raising of woollen goods. There are in all about fifteen motors installed, varying from 1h.p. to 10h.p. capacity, and each drives a single machine. There are, for instance, a row of five cloth-shearing machines, varying in width from 66in. to 170in. In Fig. 27 one of the smaller of these machines is shown, the drive being through spur reduction gearing from a 1b.h.p. motor running at 940r.p.m. Fig. 28 shows a large raising machine. This also is driven through spur reduction gearing from a 10b.h.p. motor of the slip-ring type

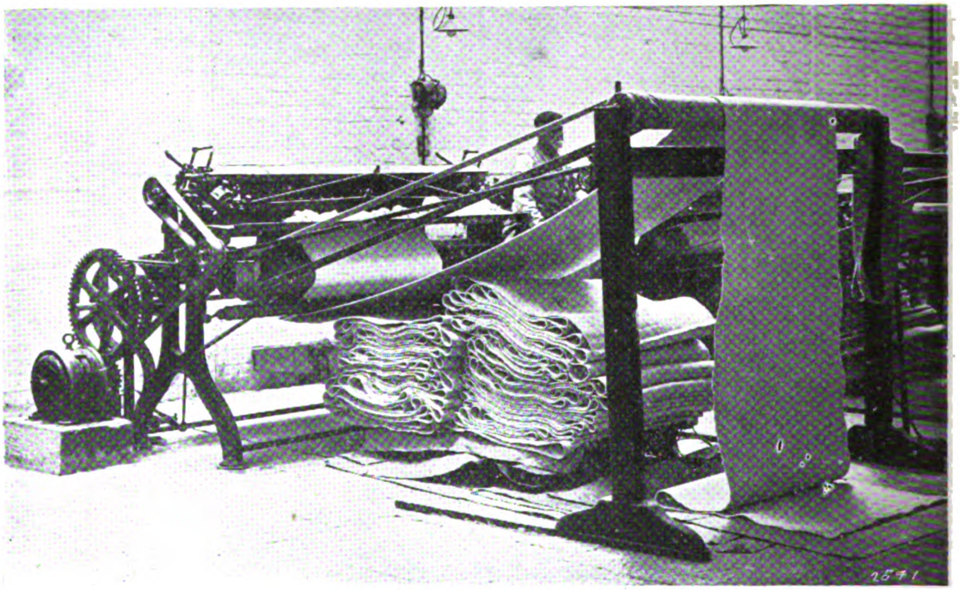


FIG. 27. METHOD OF DRIVING SHEARING MACHINES.

running at 580r.p.m. Another similar type of raising machine of a slightly smaller size can also be seen in this illustration. The motor employed in the latter case is a 5b.h.p. squirrel cage motor running at 705r.p.m.

An interesting drive of a set of hot cylinders is shown in Fig. 29 driven by spur gearing from a 1b.h.p. 940r.p.m. motor. These rollers are of a very massive type, but they run at such a slow rate of speed that 1h.p. is amply sufficient to drive them. The motor in this case, and also for the adjoining rollers (the second motor is shown in the illustration), are both reversible, being fitted with special reversing switches. In Fig. 30 a small calender is shown driven by a 5b.h.p. motor running at 705r.p.m., double reduction gearing being fitted. In this illustration the main controlling switchboard for the whole of the shed can be seen. This is an installation which should work in an extremely satisfactory manner, and in which electricity is undoubtedly the best power medium available. The Lancashire Power Company are supplying the power, which is delivered

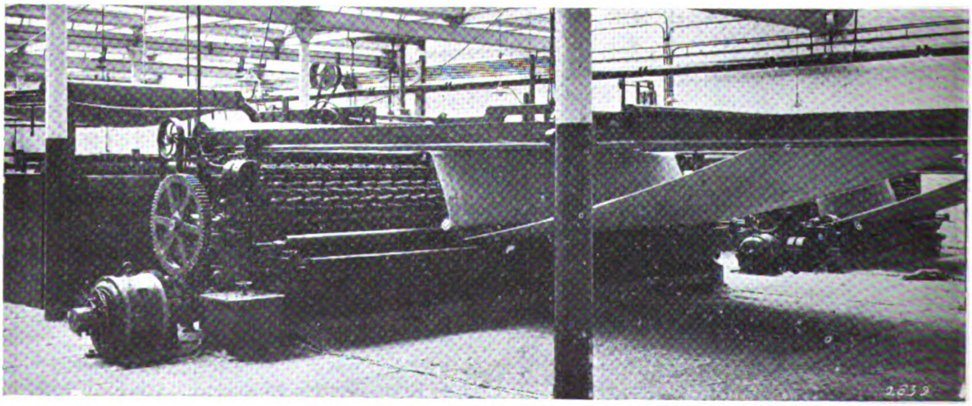


FIG. 28. METHOD OF DRIVING RAISING MACHINES.

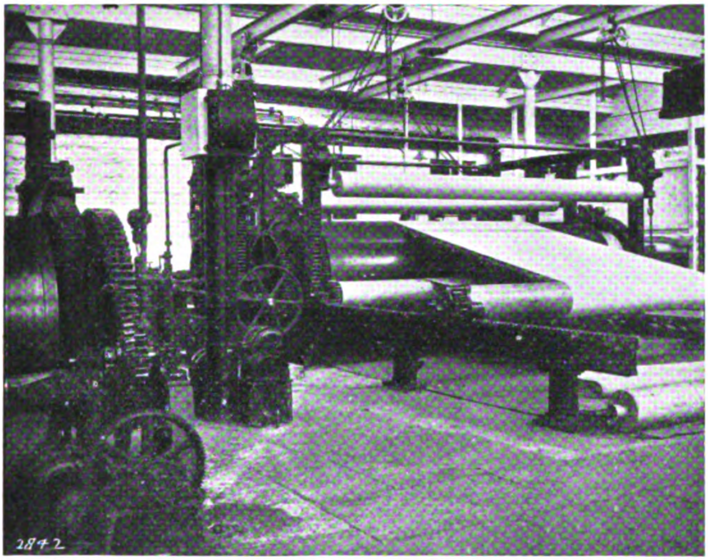


Fig. 29. Method of Driving Calenders.

at 400 volts, three-phase, 50 cycles for motors, and 230 volts for lighting. The current is conveyed to the shed from the Supply Company's transformer station, which is almost half a mile away from the shed.

One of the requirements of cotton spinners employing ring frames is a two-speed driving motor, and to meet this demand Messrs. Felten Guillaume-Lahmeyerwerke, of Frankfort-on-the-Main, have designed the motor shown in Fig. 31. Preference was expressed for three-phase squirrel-cage motors, as owing to their simplicity of construction when compared with direct-current machines, they will run for an indefinite time with no attention other than occasionally replenishing the oil in their bearings, so that no necessity to open the shell of the machine will exist, and therefore the dust and fluff which are very prevalent in spinning mills are not permitted to be deposited on the working parts. The two speeds are attained in the motor shown by the provision of two distinct stator windings, the three ends of each being connected to a triple-pole two-way switch enclosed in a cast-iron case to protect it from dust and placed on the top of the machine. The switch spindle carries an operating hand wheel on one end, while on the other there is a crank which actuates a belt-shifting fork through a link motion. The motor is started by turning the hand wheel through an angle of 45

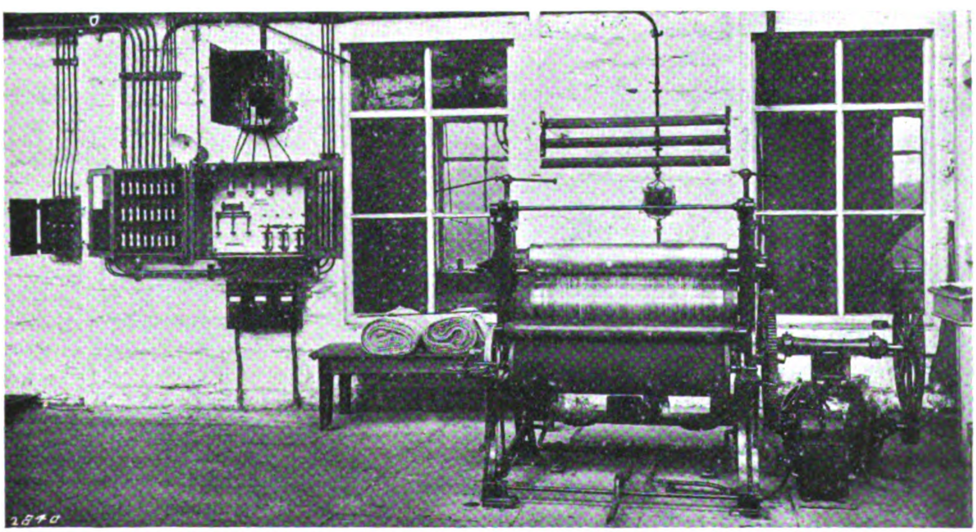


Fig. 30. Small Calender, electrically-driven.

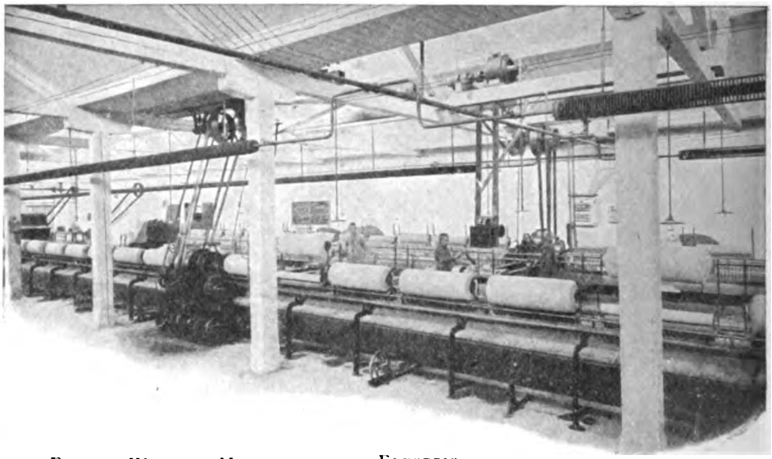


FIG. 32. WOOLLEN MULES DRIVEN BY ELECTRIC MOTOR.

deg. in the direction corresponding to the speed at which it is desired to run, and as soon as the motor has run up to the speed, the belt is moved to the fast pulley by a further motion of the hand wheel. The motor is of 7h.p. and is totally enclosed; a fan is mounted on the rotor shaft, however, and by its aid the motor works substantially as an open-type machine of equal size. In the illustration marked Fig. 32 a woollen mule is shown driven through a counter-shaft from a motor. The motor is mounted on a girder, and is a 15h.p. machine running at 1000r.p.m. The process of mule spinning necessitates a counter-shaft being employed, as the mule does not spin continuously but intermittently, occasioning the movement of the belts on their driving pulleys at the finish of each outward and inward run of the mule carriage. The warping machine shown in Fig. 34 is driven by a $\frac{1}{2}$h.p. power squirrel-cage motor running at 1400r p.m. This is a case in which individual driving is most adaptable, as these machines are placed in rooms generally apart from the spinning rooms and at the top of the mill, so that the dispensation of shafting is an advantage. In Fig. 33 one end of a dye-house is shown, the motors driving on to shafts by means of belts.

One of the most serious attempts yet made to obtain by the use of electricity something which cannot be obtained by the use of any other power in connection with spinning machinery has lately been introduced. This is the improved system of ring spinning which Messrs. Brown, Boveri, & Co., Ltd., of London, have recently perfected. The ring frame is one of the most important machines employed in the spinning industry, being, as is natural, much more productive through continuously spinning than the mule, which only spins and winds intermittently. The yarn produced on a mule, however, is much more regular, due to reasons which need not be gone into in this article. The great drawback to spinning on the ring frame is the varying tension to which the yarn is subjected as it passes from the traveller to the cop, which varies with the diameter of the pirn or bobbin upon which the yarn is being wound. In the past there have been many attempts to overcome this varying tension by mechanical means, but none have proved completely satisfactory.

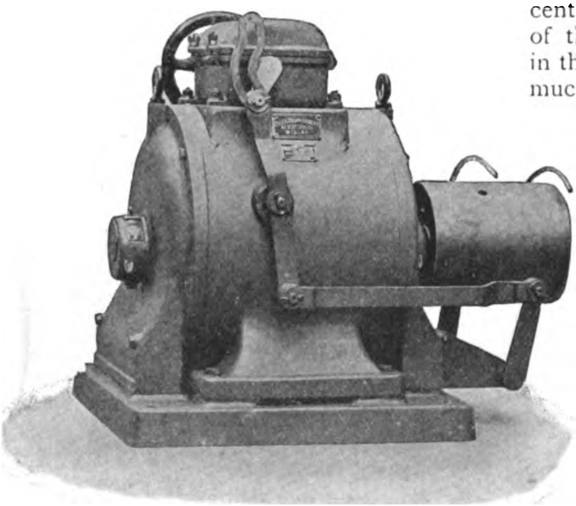


FIG. 31. MOTOR SPECIALLY DESIGNED FOR SPINNERS' USE.

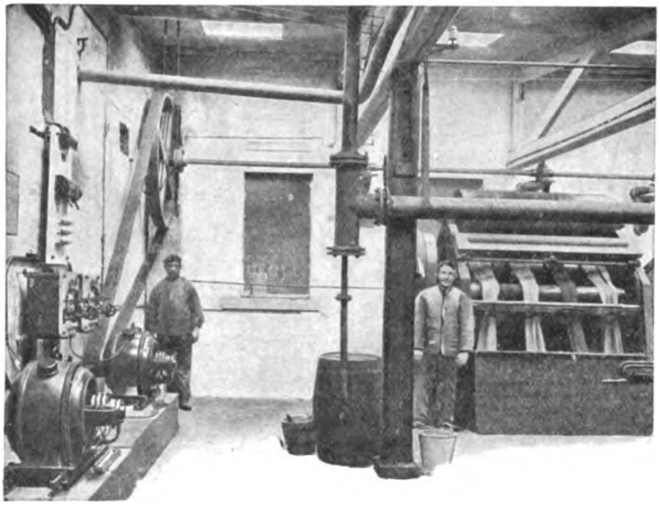


FIG. 33. DYE HOUSE, SHOWING ELECTRIC MOTORS.

In undertaking the problem Messrs. Brown - Boveri set out with the idea of utilising electricity, and the highest praise is merited by the care which has been expended in the investigations that have been made They arranged and carried out a series of experiments on ring frames while at work, from the results of which they have been able to draw out curves illustrating exactly the effect of the rise and fall of the ring rail on the thread, not only between the traveller and the cop, but also at the top and bottom of the balloon. These experiments, which were carried out with scrupulous regard to detail, were based on the varying shapes of the balloon as obtained by means of photographs, a typical example of the latter being shown in Fig. 35. Space, however, does not allow of a complete description of the investigation, which, as can be well understood, occupied considerable time. In the *Textile Recorder* for August and September a very full account of the experiments, together with the subsequent calculations, curves, and deductions, is given.

The results of these investigations led Messrs. Brown, Boveri, & Co. to the obvious conclusion that the constant speed drive which produces variations in tension of 50 per cent. or so was wrong, and that the frames should be driven at a speed which should vary with the rise and fall of the ring rail, or, in other words, with the varying diameter of the pirn or bobbin on which the yarn is being wound. Moreover, they found that the tensions between the traveller and the cop, and between the front roller and the thread guide, do not vary to the same extent. After the thread passes through the traveller it has received its full twist and strength, but as it leaves the front rollers it has very little twist at all, and hence is very susceptible to stresses tending to stretch it. It is therefore the tension between the front roller and the thread guide that should be kept constant, in order to improve the spinning.

Again, they found that the tension on the thread at this point not only varied with the rise and fall of the ring rail, but depended on what part of the cop was being formed, being greater when the base of the cop was being formed than when the bobbin was half full. Having determined the exact conditions prevailing, Messrs. Brown, Boveri, & Co. devised a patented system of working which embodies all the characteristics which they have found necessary to obtain the best results.

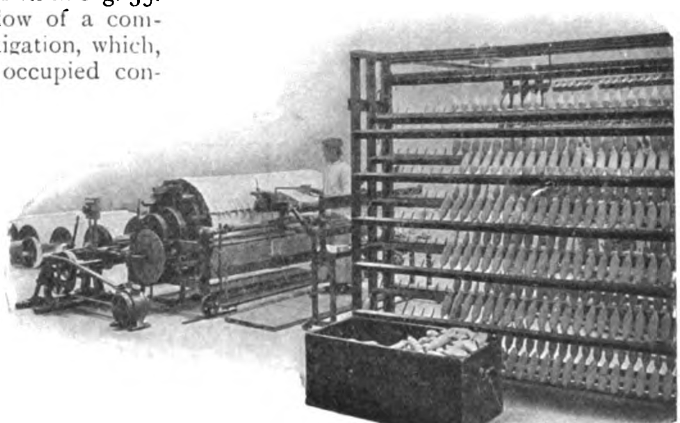


FIG. 34. WARPING MILL, ELECTRICALLY-DRIVEN.

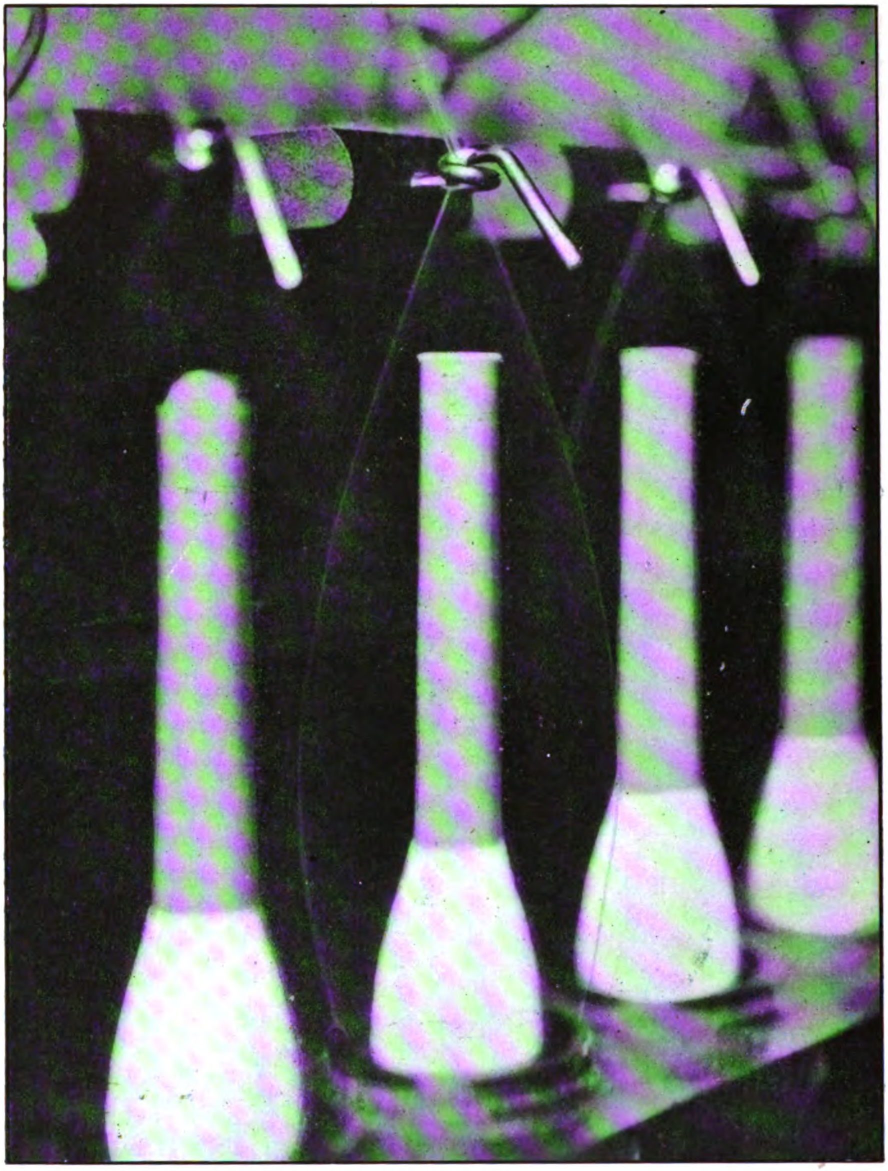


Fig. 35 Photograph of Typical Balloon formed in Ring Spinning

For driving the frame they use a single-phase commutator motor of special design (Fig. 36) and construction, which is coupled to the tin roller shaft. Its principal feature is that it is started and stopped and its speed controlled entirely by one simple lever which operates the brush rocker; no resistances, choking coils, or auxiliary windings of any description are used, and the motor can be made to run at any speed between rest and the highest by a simple movement of this lever. Between the limits (generally some 40 per cent.) of speed variation required by a ring frame, the motor efficiency remains almost constant.

This handle is operated by an automatic gear of very simple design, which is itself driven from the headstock of the frame. This automatic gear consists essentially of two cams; the one, which varies the speed

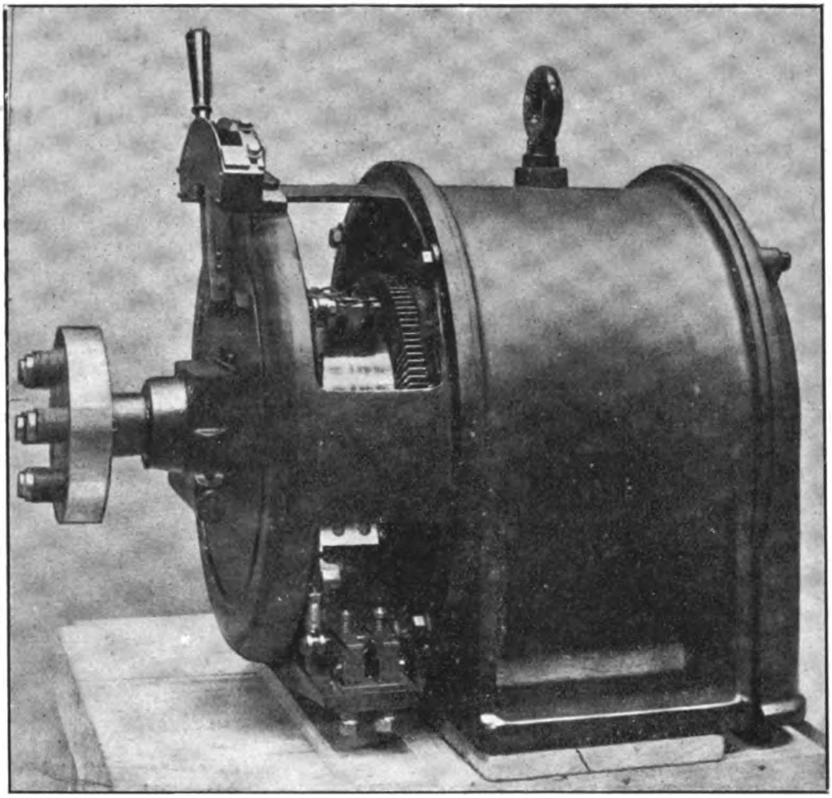


FIG. 36. SPECIAL MOTOR, BROWN-BOVERI SYSTEM.

with the rise and fall of the ring rail, is driven from the heart shaft; and the other, which controls the limits of speed variation, from the ratchet wheel. The two cams operate two lifting levers which are linked together, the combined motion from which is communicated to the controlling handle of the motor by means of a cord. By suitably shaping these cams the speed of the frame can be made to vary in any desired way from start to doffing. These cams can be replaced by others when the count, &c., are changed. The practical advantages that Messrs. Brown Boveri & Co. state are obtained from this system are:

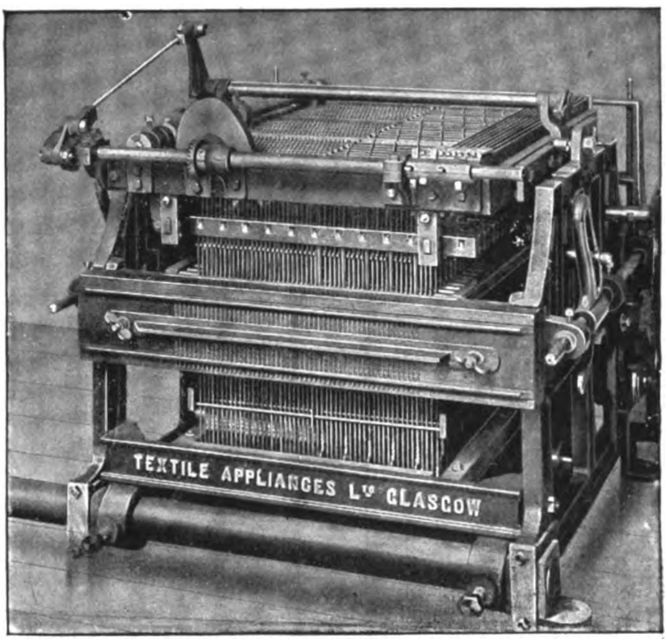


FIG. 37. SELF-TWILLING JACQUARD MACHINE.

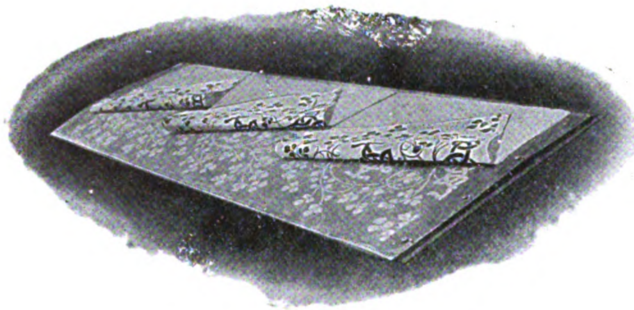


FIG 38 PRINTED METALLIC SHEET.

(1) Better spinning, as, the tension on the thread as it leaves the front rollers being always constant, the yarn is treated in a perfectly uniform manner; (2) better wound cops, as, the above-mentioned tension being constant, the tension between the traveller and the cop, though not quite constant also, will be much more uniform; (3) fewer breakages, as the tension maintained can be lower than the maximum which occurs with constant speed drive when winding on the bare bobbin; (4) increased output, as it is necessary, in order to maintain the constant tension, to very much accelerate the frame when spinning on to the large diameters of the cop.

The last is certainly a very important advantage, and should induce spinners to try the arrangement, especially as it is obtained not at the expense of, but on account of the improvement in the spinning. The increase of output naturally varies, but 15 per cent. is quite common, and in one or two cases nearly 25 per cent. has been obtained. A further advantage is that the equipment can be applied to any standard make of ring frame without necessitating material alterations. On the Continent several hundred equipments are at work giving considerable satisfaction to the users.

As foreshadowed in the earlier portion of this article it is our intention to discuss intimately a few of the many special applications of electricity to processes involved

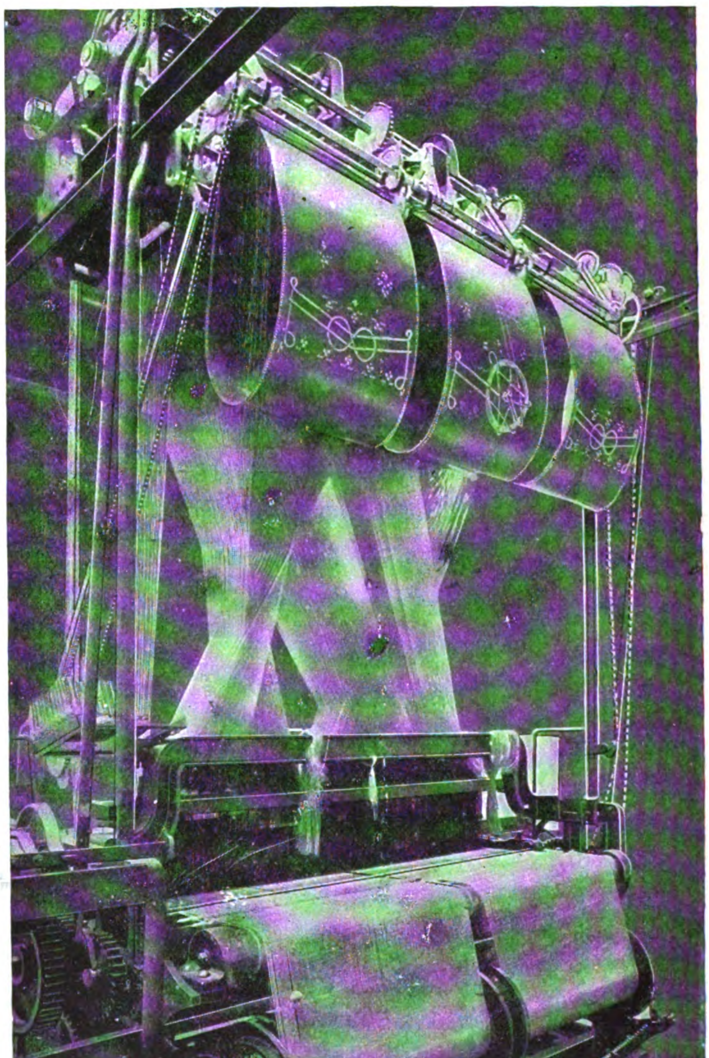


FIG. 39. METALLIC DESIGN SHEETS ON LOOM.

FIG. 40. METALLIC DESIGN SHEET FORMED INTO CYLINDER.

in the textile industries. It has been proved beyond question that in certain cases electricity is of immeasurable value to various sections of the textile trades quite apart from its value as a power unit. By its use, arduous work has been obviated, machines and appliances simplified, and, as a natural result, production increased and cost decreased. Take for instance the Carver electric system of figured weaving. By this system intricate patterns are woven without recourse to pattern cards, which are not only expensive to produce, but are also cumbersome to handle, with the result that labour and cost are considerably reduced. The following figures, which show a comparison between the cost of preparing a design for an eight-quarter linen damask table-cover by the card method, and by the Carver system, prove this statement thoroughly. Such a cloth, woven by three 600 machines, with 112 shots or picks of weft per inch, and with 60in. of unrepeated design, requires, if one card is cut for every shot of weft, 20,160 cards. To reduce the cost, however, of so great a number of cards, in practice one card is not cut for every shot of weft, two shots being as a rule taken from each card. The number of cards required therefore would be 10,080. The following figures are thus obtained :—

CARD METHOD.

1. 2 *Shots per card.* Sketch and paintings from sketch ...	£45	0	0
10,080 cards at 3s. 6d. per 100	17	13	6
	£62	13	6

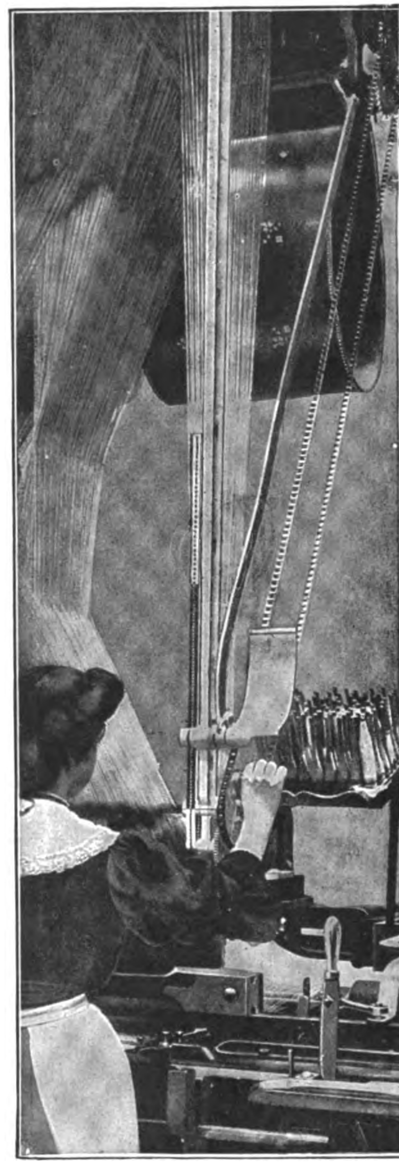


FIG. 41. WEAVER'S CONTROL DEVICE.

2. 1 *Shot per card.* Sketch and paintings from sketch ...	£90	0	0
20,160 cards at 3s. 6d. per 100	35	7	0
	£125	7	0

CARVER SYSTEM.

1 *Shot per card effect.* Design ready for copying	£10	0	0
Metallic patterns ready for looms	1	12	0
	£11	12	0

C

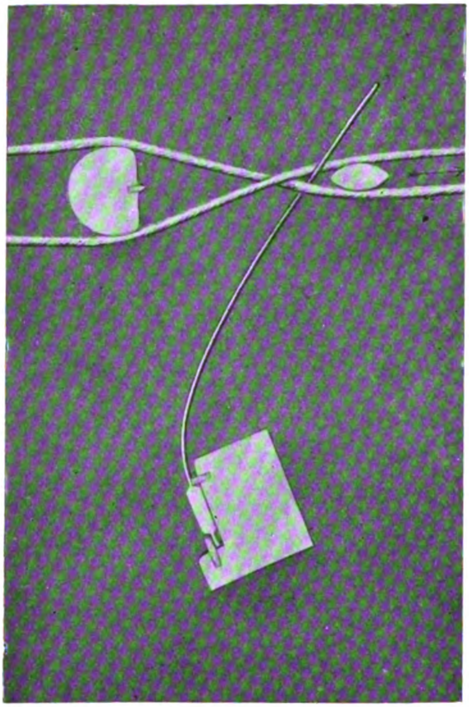


FIG. 42. SHOWING PRINCIPLE OF WARP-STOP MOTION.

The difference in the foregoing totals is tremendous, and the figures are well authenticated. It will be as well to follow the Carver system in detail to see how this wonderful result is arrived at.

In the first place the Carver Looms, Ltd., of Glasgow, employ the self-twilling Jacquard. The object of this machine is to produce the binding weave in the ground and in the figure automatically. Hitherto these machines could only be used when the twills throughout the ground and figure of the cloth were the same. To extend the use of the self-twilling method this company has developed self-twilling machines to perform any of the twills or combinations of twills in ordinary use in damask weaving. Their standard machine works either 5-leaf ground and 5-leaf figure, or 5-leaf ground and 8-leaf figure, or 8-leaf ground and 8-leaf figure. The machine illustrated in Fig. 37 is arranged to give 5-leaf ground and 8-leaf figure. By the employment of this self-twilling arrangement all necessity for the Jacquard which has to be employed to produce the figure to produce twilling as well is removed. Having therefore got over the difficulty of twilling, the inventor has been enabled to apply very much advanced methods to the treatment of the Jacquard and its supplementary appliances. One great feature in favour of the device is that it can be applied to existing self-twilling machines or other Jacquard machines when the general weave is automatically performed in the space of a few hours. The figure is woven from a photographic copy of the design upon thin sheet metal which controls the attachment, to operate the Jacquard machine in a manner identical with the action of the cards. A metal sheet just printed is shown in Fig. 38. For the standard 600-needle machine the width of the metallic pattern is 21in., the length depending upon the length of the design. The design is simply a sketch drawn in opaque ink on transparent paper, and forms a negative from which the metallic pattern is directly prepared. In Fig. 40 the metallic pattern is shown joined into a cylinder for working. The cylinders are fitted to the loom as shown in Fig. 39, and the weaver can control the pattern and turn it back or forward as shown in Fig. 41 at will. The

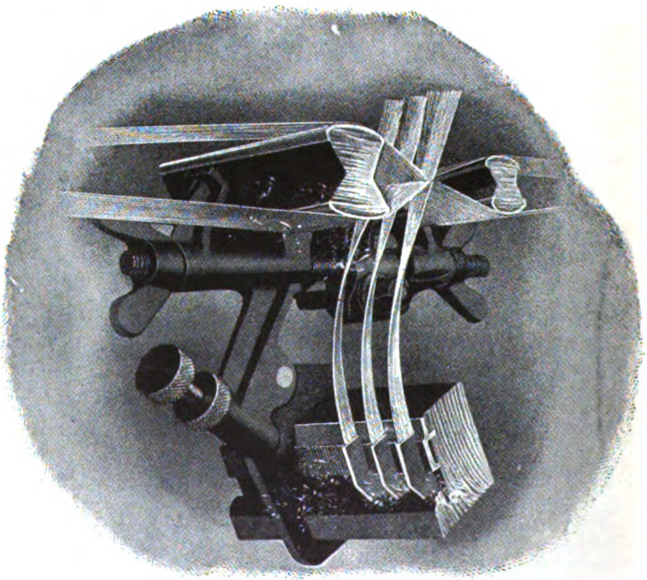


FIG. 43. APPLICATION OF WIRES TO WARP.

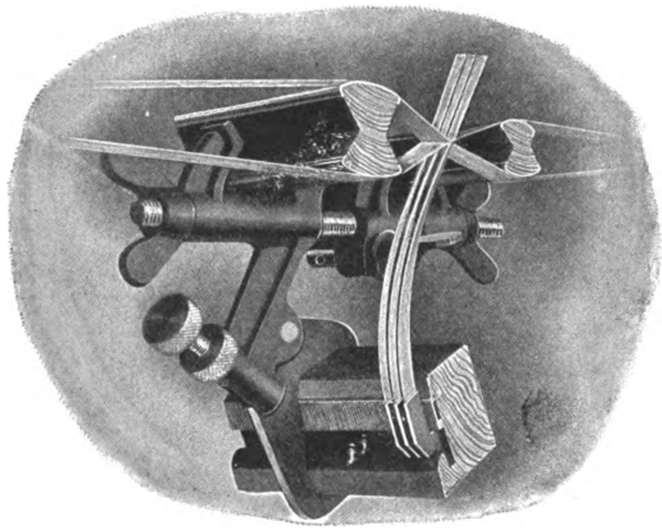


FIG. 44. APPLICATION OF WIRES TO WARP.

produced the machine just described, and the warp-stop motion, a description of which follows. The importance of warp-stop motions cannot be too greatly emphasised. By their use the figured patterns are maintained perfect, weavers can attend to more looms, and great economy is effected. The principle of a warp-stop motion is that immediately a warp thread breaks the loom is stopped. The firm whose name we give above have introduced an admirably devised warp-stop motion which has been proved successful. In Fig. 42 the principle of the motion can be seen. A wire is employed which in passing between two crossed warp threads at the lease rods is so pressed forward that it has a constant tendency to spring back. Should either of the threads break the wire is released and it springs back, closing a circuit by touching a metallic strip on the lease-rod. It will, of course, be understood that for every two threads of warp one wire is employed, and in Figs 43 and 44 a series of wires in position are shown, the first being for a slay with a comparatively small number

needles of the Jacquard machines are selected and operated by making a contact with the metallic plate. Where there is no pattern no contact is made and consequently the needle is not operated. By a special arrangement the length of pattern woven is indicated to the weaver and the whole arrangement is such that the weaver has complete control over it. The ease with which a set of patterns can be changed is considerable. Changing is much more easy with the metallic plate than with a set of cards. The cloth produced has a finer appearance, the pattern being more regular on account of the 1 shot per card effect the system always secures. The speed of the looms can be increased in certain cases, as much as 20 per cent. greater production being obtained. The metallic patterns do not obstruct the light in the factory, which is a further big advantage.

The Carver Looms, Ltd., and Textile Appliances, Ltd., both of Glasgow, are amalgamated, and in conjunction

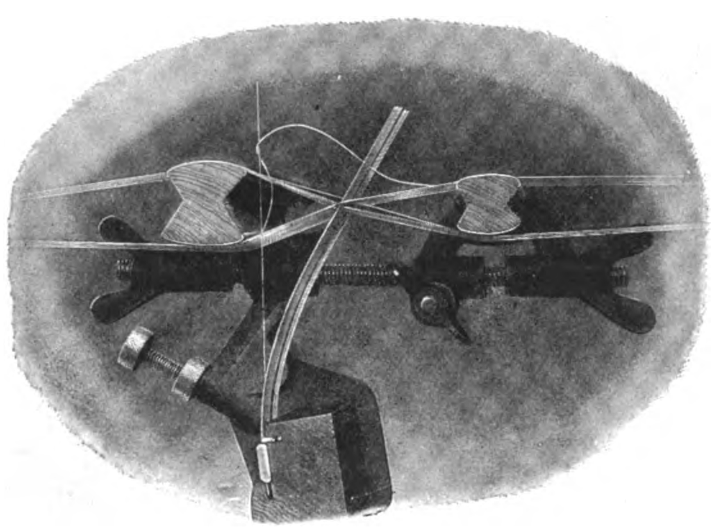


FIG. 45. SHOWING MOVEMENT OF WIRE ON BREAKAGE OF THREAD.

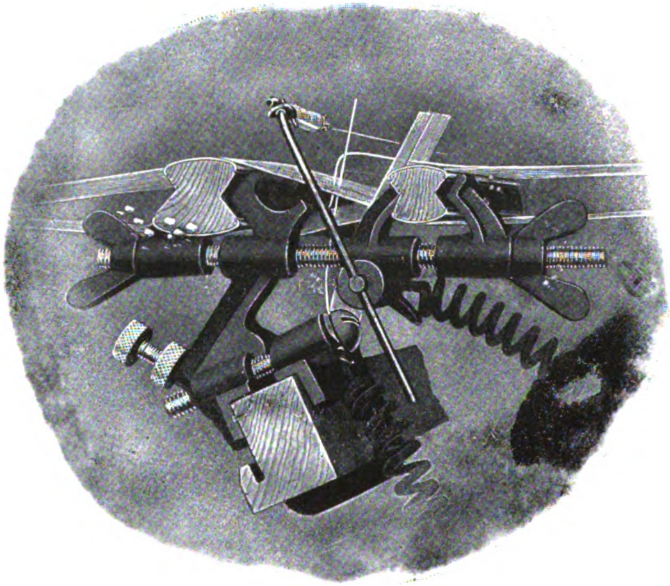


Fig. 46. Contact Frame.

off motion is simple, and the power required to do this is supplied by some moving part of the loom itself, and not by the electrical mechanism, which merely brings the parts into line for the action. Certainly these inventions display a considerable amount of insight into the requisites of the weaving industry, and are excellent examples of the specialised use of electricity.

Certain classes of yarn are subjected to a singeing process for the purpose of burning away the short fibres which protrude from the round cylindrical body of the thread. The yarns so treated acquire a polish and a smoothness which is of extreme value. Sewing cotton threads are invariably subjected to this treatment, and yarns which are subsequently mercerised

of dents to the inch, and the latter for a slay with a comparatively large number of dents to the inch. A small amount of spring is sufficient to give positive action on the breakage of a thread, because the force is applied directly in the line of the warp. The movement of a wire upon the breakage of a thread is shown in Fig. 45. In Fig. 46 the contact frame with adjustable contact slip is shown. The contact slip is made adjustable to give any degree of sensitiveness that may be necessary for any class of work, so that if necessary the loom can be stopped upon even a s'ight slackening of the thread. The whole device is well constructed, and can be employed in connection with any make of loom or in the production of any class of fabric. In Fig. 47 the device fitted to a loom is shown. The knock-

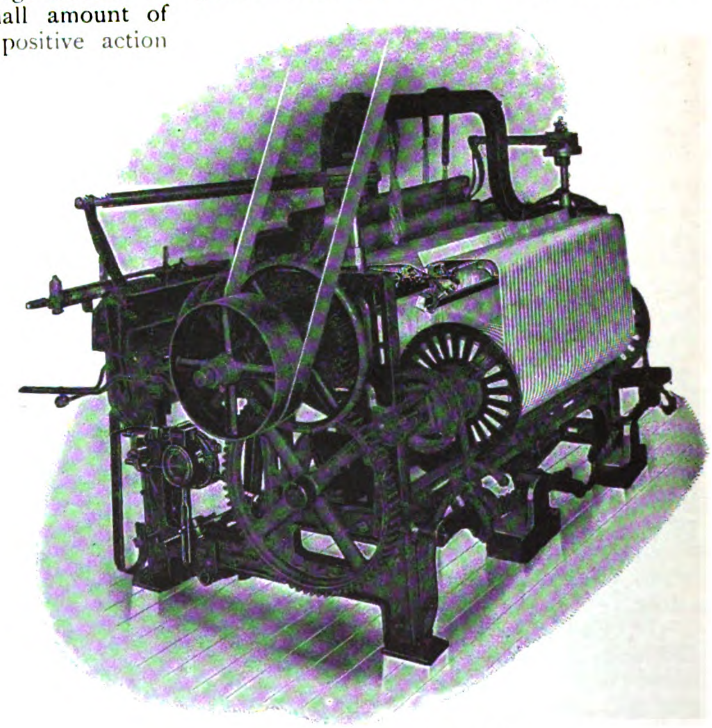


Fig. 47. Warp-stop Motion Fitted to Loom.

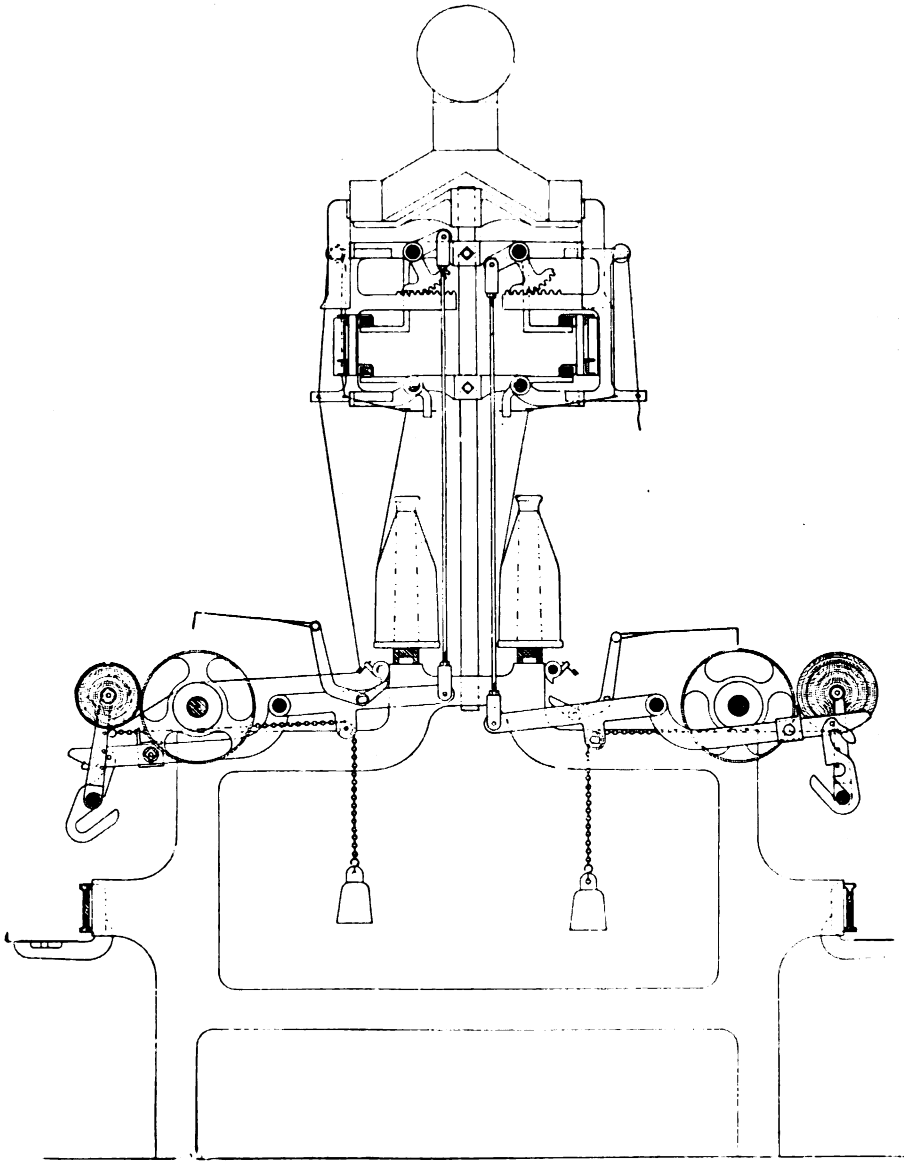
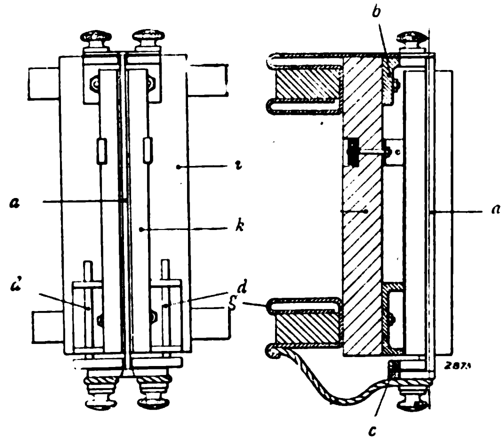
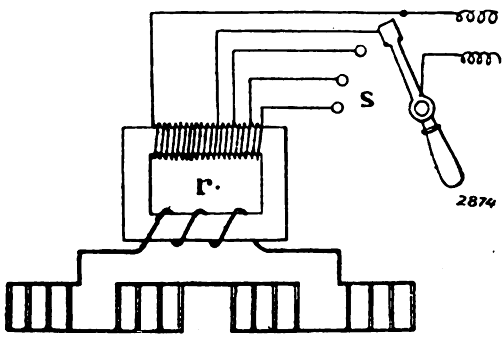


FIG. 48. SECTIONAL VIEW OF ELECTRICAL SINGEING FRAME.

should always be thus treated if a subsequent high lustre is sought. The machine employed for the purpose has long been known in the trade as a "gassing" frame. As the term implies gas is employed, and essentially the machine consists of a number of winding heads each provided with one or more small Bunsen burners through the flame of which the thread is drawn rapidly one or more times. This passage of the thread through the flame serves to singe the loose short fibres from the surface. It is somewhat to be wondered at that electricity has not been thought of hitherto as a suitable medium for the purpose. A French invention has lately been introduced into this country, and machines are to be manufactured here by the firm of Messrs. Arundel & Co., Sovereign Works, Stockport. In Fig. 48 we show an illustration in line





FIGS. 49, 50, AND 51. DETAILS OF SINGEING DEVICE AND ARRANGEMENT OF WIRING.

of a frame made by this firm, and in Figs. 49 and 50 details of the singeing device. The latter consists of a platinum tube *a* connected by means of its terminal lugs with two metal clamps, one of which, *b*, is fixed, whilst the other, *c*, is free. The latter carries rods, *d*, capable of sliding in the guide apertures of the U-piece. The lugs of the burner are fastened to the clamps by means of milled head screws. The connecting clamps are connected with the current leads by spring clips *g*, and the junction between the movable clamp and the corresponding clip is effected by flexible cables as shown. The two slips and the fixed clamp are mounted on a baseplate of slate or ebonite, *i*, to which is also attached a porcelain casing, *k*, to lessen the loss of heat by radiation from the platinum tube. In constructing a full-sized frame several of the units are grouped in parallel, and then a certain number of these groups are arranged in series, as is shown in Fig. 51. The current is supplied to the outermost bars by a special transformer shown diagrammatically at *r*, which receives the primary current at the tension of the main, and supplies the secondary element with current at a tension and density corresponding to the number and dimensions of the units, and in accordance with the desired temperature. The temperature of course depends upon the counts of yarn, and the speed at which the yarn is being wound. The temperature may be regulated by varying the number of turns of either the primary or secondary windings by means of a step commutator. It is claimed for the electrical singeing of yarn that the system is more economical, and is much more healthy. There is stated to be a more complete utilisation of heat effected, but at the same time only a small quantity of heat escapes into the room, and there is no injurious gas produced apart from the carbon dioxide resulting from the combustion of the small projecting fibres. The tables on page 330, issued by the French firm interested in this machine, which are stated to be the result of careful tests, give the annual expense in two works, one employing gas for singeing and the other electricity.

The employment of hydro-extractors is large and the use of electricity in connection with them follows almost naturally. The construction of a hydro-extractor electrically driven can be seen from the line illustration marked Fig. 52. The material to be dried is placed in the receptacle at the top of the illustration, and the motor started up to revolve the drying receptacle round a central supporting spindle or shaft. In the arrangement as shown, the application of the motor to the extractor, has been the result of much experiment and careful thought, and the makers, Messrs. Thomas Broadbent & Sons, Ltd., Huddersfield, deserve all praise for the results they have obtained. The various parts employed are as follows:

It will be seen that the electric motor is an inherent part of the machine. The armature revolves upon the centre spindle, which carries the basket or receptacle, and the field magnets are built into the framework of the machine. All movement in the machine is rotary. All the windings of the motor are completely enclosed in an iron casing, so that there is absolutely no possibility of their being damaged by damp or oil. As no parts protrude from the outer

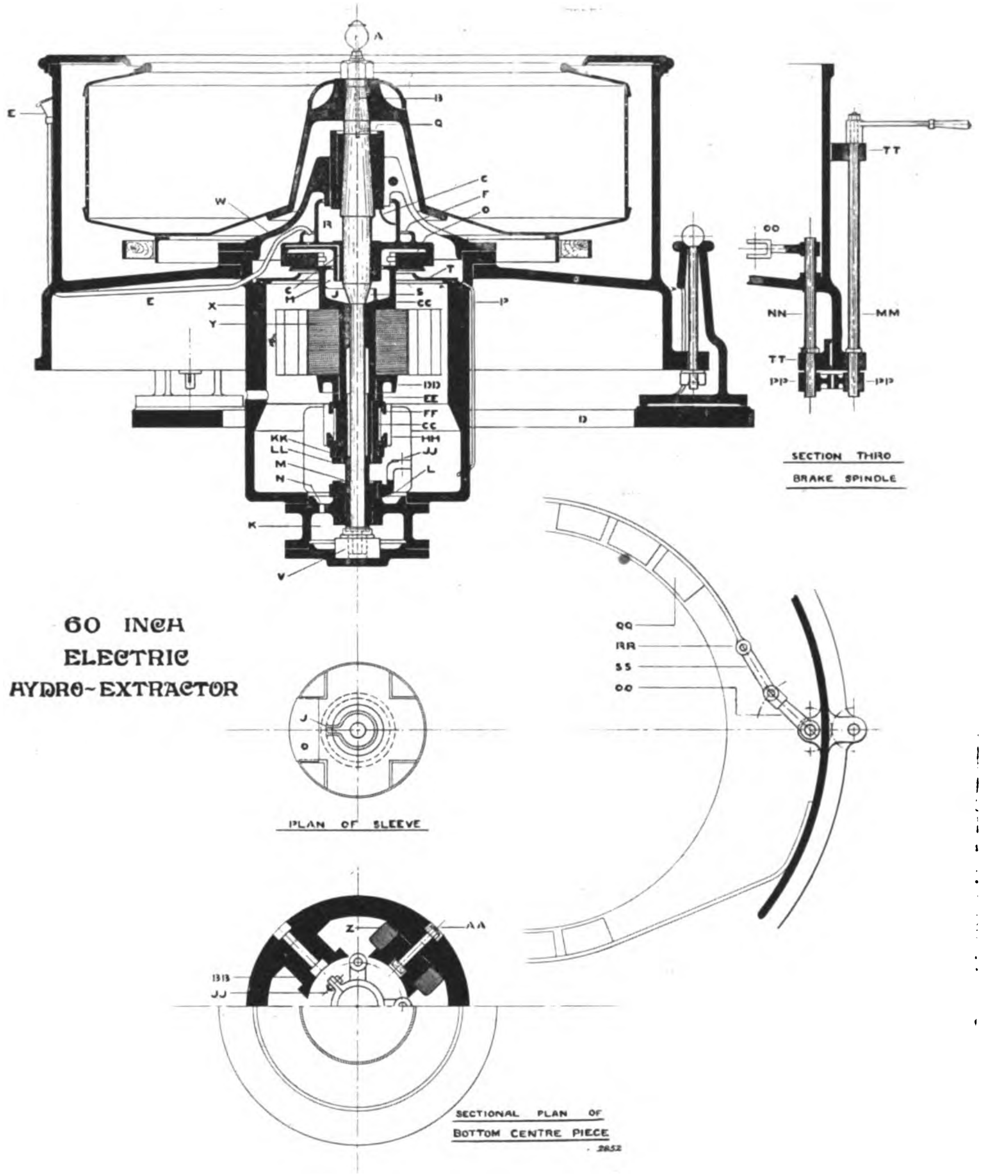


FIG. 52. AN ELECTRIC HYDRO EXTRACTOR.

casing, the floor space occupied is very little more than the diameter of the basket or the width of the framing. An ingenious method of rendering quite unnecessary any complicated starter and resistance is introduced. This arrangement consists in mounting the armature upon a sleeve which is independent of and can revolve round the centre spindle of the machine. To the upper part of this sleeve are attached friction shoes which are thrown out by centrifugal force when the armature commences to rotate. The weight of these shoes is regulated so that when the motor attains its normal speed the friction developed is equal to the power of the motor. The hydro-extractor is then gradually brought up to its proper running speed, although the armature

Yarn No.	Rate of Winding.		Weight of Yarn Gassed per Head per Diem.		Consumption per Kilo. of Yarn.		Cost per Kilo. of Yarn.		Remarks
	Gas Metres.	Elec-tricity Metres.	Gas. Kilos.	Electricity. Kilos.	Gas. Litres.	Electricity. W. H.	Gas. Francs.	Electricity. Francs.	
33	180	400	3.150	7.000	176	113	0.026	0.009	2in. Inverted flame.
50	240	400	2.700	4.500	205	150	0.030	0.012	
60	240	400	2.700	3.840	241	184	0.036	0.015	
100	320	400	1.920	2.400	290	220	0.043	0.017	1½in. Inverted flame.
127	370	400	1.740	1.880	320	250	0.048	0.020	
127	247	400	1.170	1.900	374	280	0.056	0.022	1in. upright flame.
144	256	400	1.065	1.620	409	320	0.061	0.025	
169	298	400	1.060	1.380	412	350	0.061	0.028	
186	325	400	1.050	1.260	416	370	0.062	0.030	
203	325	400	0.960	1.100	438	395	0.063	0.032	
211	350	400	0.995	1.140	437	420	0.063	0.033	
220	350	400	0.955	1.090	448	450	0.065	0.035	

Yarn No.	Annual Production.	Consumption.		Cost.		Annual Saving.
		Gas.*	Electricity.	Gas.	Electricity.	
	Metric Tons.	Cubic Feet.	Kw.	£ s.	£ s.	£ s.
33 bl.	94.5	586,000	10,700	100 0	34 4	65 16
50 bl.	81	572,000	12,200	97 12	39 0	58 12
60 fl.	69	590,000	12,700	100 8	41 12	58 16
100 bl.	57.6	590,000	12,700	100 8	41 12	58 16
127 bl.	52.2	593,000	13,000	100 16	42 0	58 16
127	35.1	466,000	9,800	79 8	31 8	48 0
144	32	462,000	10,400	78 16	32 12	46 4
169	31.8	462,000	11,100	78 16	35 8	43 8
186	31.5	466,000	12,500	79 8	40 0	39 8
203	28.8	413,000	11,400	76 8	36 16	39 12
211	29.5	420,000	12,400	77 12	39 12	38 0
220	18.7	296,000	8,400	50 8	26 18	23 10

is of course running at its full speed the whole of the time. The advantages of this arrangement are: (*a*) that the starting up of the machine is quite automatic; (*b*) that the attendant cannot damage the motor by switching on the current too suddenly; and (*c*) that the starting current never exceeds a maximum figure, which can be definitely fixed in designing the machine. The machine runs steadily and smoothly, the latter being largely due to all the moving parts being rotary.

THE APPLICATION OF ELECTRICITY TO COLLIERY WORK.

GERALD HOOGHWINKEL, M.I.E.E., M.I.M.E.

WHAT not more than five or six years ago was a comparative novelty is by now a well-established and rapidly spreading auxiliary for colliery work. Even more, the electric power station is becoming, as it should be, the first consideration when a new colliery plant is being laid out. For although the application of electric driving to pumps, haulages, fans, and surface machinery has been established for a considerable time and has given good results where properly designed and installed, yet the complete electrical equipment of a colliery, from the sinking onwards, is only recent practice, at least so far as this country is concerned. On the Continent, and especially in Germany, several complete electrical installations (including the main winding) existed many years ago, but we have only lately seen the adaptation of this practice to our own collieries. It may be well to explain the reason for this caution on the part of British colliery owners, for even at present the idea prevails that our colliery owners are still waiting for the good results said to have been obtained abroad before following in the same direction. In Germany many of the larger collieries, steel works, &c., are under the control of powerful financial groups, who at the same time are allied with the large electrical manufacturing interests as they exist in that country. The electrical industry, being in the hands of ten large, well-managed, and well-engineered concerns, was able to design, experiment, and develop electrical mining plant on a large scale long before the actual demand was created. The writer, having been engaged on these primary efforts, may perhaps be allowed to emphasise the advantages of such an organisation so far as electrical progress is concerned. The collieries, being mostly in the hands of large companies with ample means, were able to avail themselves of this new machinery as soon as it was properly tested and developed. This accounts for the wholesale introduction of electrical machinery, even including electric winding plant, in the German collieries six or seven years ago. Other special causes also contributed to this, such as the relatively high price of coal, the great developments of the new coalfields, and the more scientific training of German mining managers. Many of these differences between British and German practice have since disappeared, and it may therefore be confidently expected that electricity will be employed for mining work in this country to the same or even a greater extent than abroad. Much can be done in the attainment of this end by our large electric manufacturing firms, our mining engineers and directors. The manufacturers should improve and develop their plant before the actual demand is felt, and so always keep in front. The mining director should avail himself of the services of competent consulting electrical engineers to design his plant and advise him as to the electrical developments. It cannot and should not be expected that managers and mechanics at the mine have such complete and thorough knowledge of electrical methods as to be able to design, specify, and choose the best electrical plant to suit their particular requirements.

It is curious to notice that the first appli-

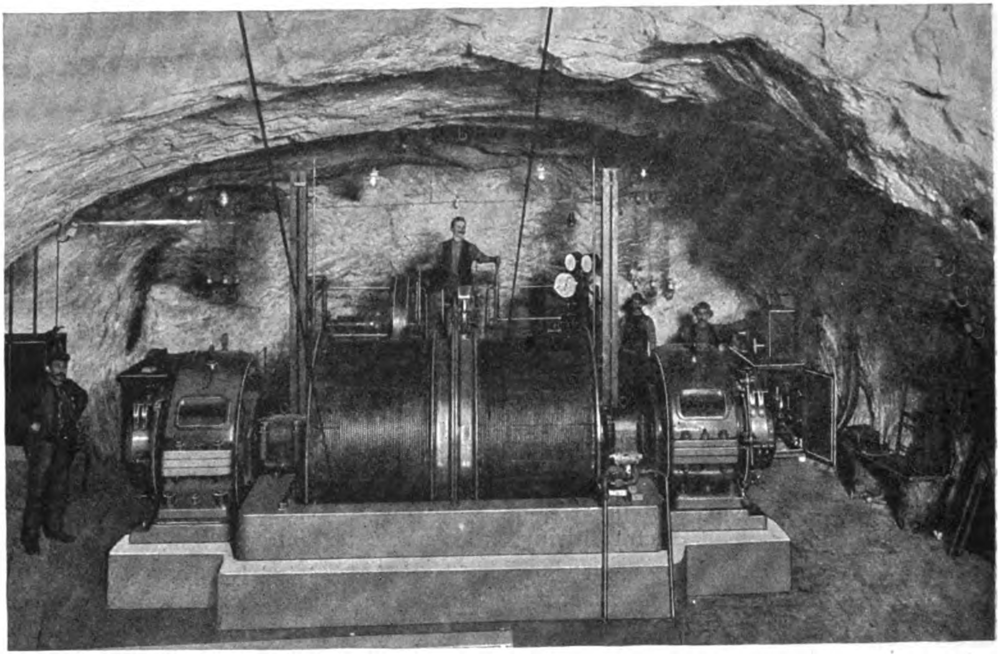


Fig. 1. Underground Electric Winding Engine with Direct-current Motors.

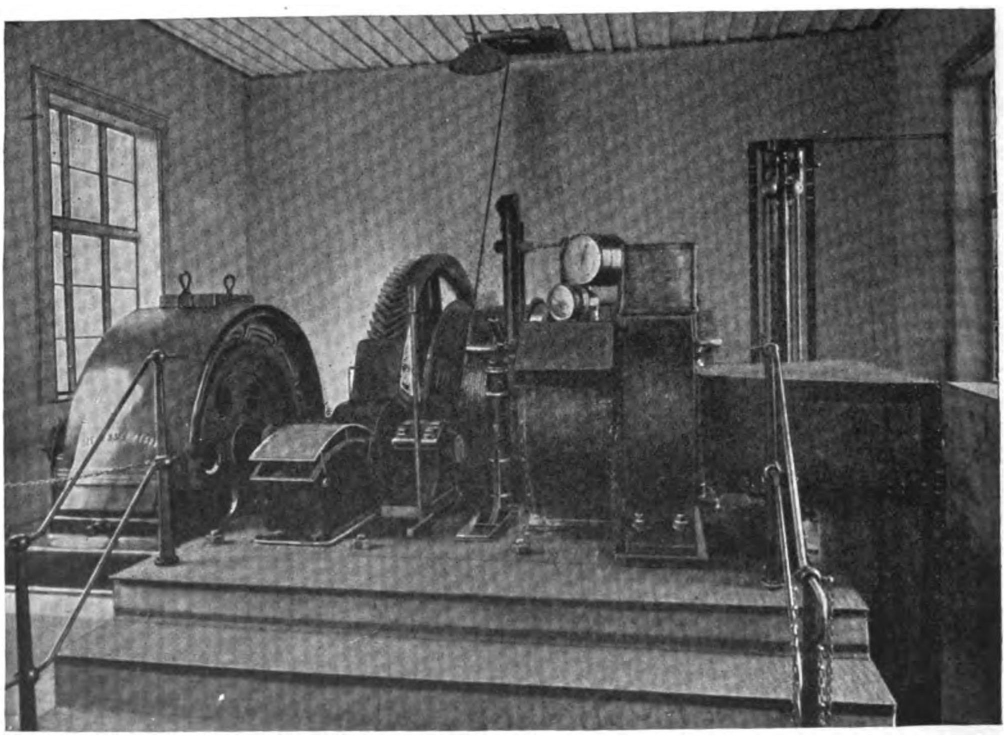


Fig. 2. Electric Winding Engine with one Three-phase Motor.

cations of electricity to colliery plant were for pumping and fan driving, although in both cases the advantages, at least so far as regards economy in running costs, were not apparent. As a mattter of fact the advantages of electric driving for pumps and fans are principally appreciated in the power station, where they have a beneficial influence on the load factor. From this point of view the results will be very satisfactory, taken in connection with the electrical generating-plant. It is true that since the introduction of the electric drive for pumps and fans the tendency has been for high-speed plant, which has had considerable influence on the first cost. From this point of view it may be said that there is no better combination than the electrically driven high-lift centrifugal pump and "Sirocco" type of fan. Where, however, the real saving in working costs, and therefore in coal consumption, can be obtained is in the intermittent drives, such as main-and-tail haulages, main winding and electric drills. The former of these applications is now fairly general, and in new and up-to-date collieries few steam-driven main-and-tail haulages will be left. As to winding, this opens up a very large field, and has provoked numerous discussions, but as the writer has been identified with the first steps in this direction he may be allowed to deal with this application in the first place. One point should here be emphasised, and that is that electric driving is more economical the more generally it is applied; in other words, the more electrically-driven plant a colliery possesses, and the larger the plant, the greater the proportional saving in coal and wages. Therefore, the more completely a colliery, with its favourable diversity and load factors, is electrified, the better the result in comparison with steam. From the very first electricity should be used during sinking, for the pumps, sinking frame, drills, and other work, but should be so arranged that the first plant units will fit in later with the general scheme. Sometimes this may lead to the adoption of too large units, but this is not so disadvantageous as it looks at the first glance, especially if steam turbines are adopted; it will be found more economical to run the larger unit on half load than to install a smaller unit which could be run at full load. The same applies in the case of the night and day loads. It is better to install the larger units in such a way that one or two can take the full day load, and one of them the night load, than to put down a smaller and less economical unit for the latter load. With steam turbines it is possible, even in large collieries, to run the entire plant from one, or at most two units. The large overload capacity of the steam turbine enables one set to cope with sudden and frequent overloads, and the running and maintenance as well as the capital charges will be found to decrease considerably with the number of units.

We will now briefly touch on the latest developments in the methods of electrical driving of winding engines, haulages, pumps, fans, and surface plant.

Electric Winding.

Winding is by far the most important application of electricity to mining plant; important because its adoption requires considerable outlay in replacing existing steam plant in good condition, and also because the saving in fuel and other costs is so considerable. At the same time, it is to be noted that the introduction of electric winding has been entirely neglected in this country. The writer proposes to shortly enumerate the most striking advantages of electric over steam winding, to describe the different systems employed on the Continent and in the United States, and to give a more detailed description of the most modern plant with the design and erection of which he has been connected.

It must be remembered that the capacity of the winding plant is all important, and it is often the only limiting factor to the output of the mine.

The slightly increased cost of the plant should not be considered as important, and mine-owners should not hesitate to install up-to-date electric winding plant if they are convinced that the output of the mine can thereby be increased, and the working cost per ton decreased. In a case of which the writer had personal experience, by the substitution of electric plant for steam plant the mine output was nearly doubled; at the same time the coal consumption was halved. The advantages of electric winding over steam winding may be enumerated as follows:—

1. Saving in coal consumption (often reduced to half).

2. The possibilities of using water power or blast furnace gases as prime power, at low cost.

3. The possibility of winding at several shafts from one main central power station.

4. Stability of the winding speed with shunt and three-phase induction motors, even when putting energy back into the system, while steam winding machines may run away through negligence of the engineman. The speed, and therefore the security, of a steam winding plant depends entirely upon the engineman, and in order to ensure security he generally decreases the mean speed, and therefore, also, the output, during a shift. With electric winding there is a moral feeling of security on the driver's part which must not be disregarded.

5. The torque of the electric motor on the winding machine shaft is at any moment and in any position of this shaft the same, whereas with a steam engine it changes with the position of the cranks, and causes dangerous vibrations in the winding rope, even where two coupled high-speed engines are used. The winding ropes may last at least twice as long, as the writer has been able to verify from personal experience.

6. The possibility of taking from the engines in the power station only the required average power by installing equalisers.

7. The possibility of lifting a heavy overload (two or three times the ordinary load), which is impossible with a steam plant, as the engine is designed for a certain maximum cut-off corresponding to the maximum energy.

8. The possibility of easily checking the costs at any moment by the electric wattmeters.

The first costs are about the same for small winding plants, whether steam or electricity is employed, because it is possible to install the engine on the winding frame. In the case of larger plants, electric winding plant is slightly dearer, taking the machines only.

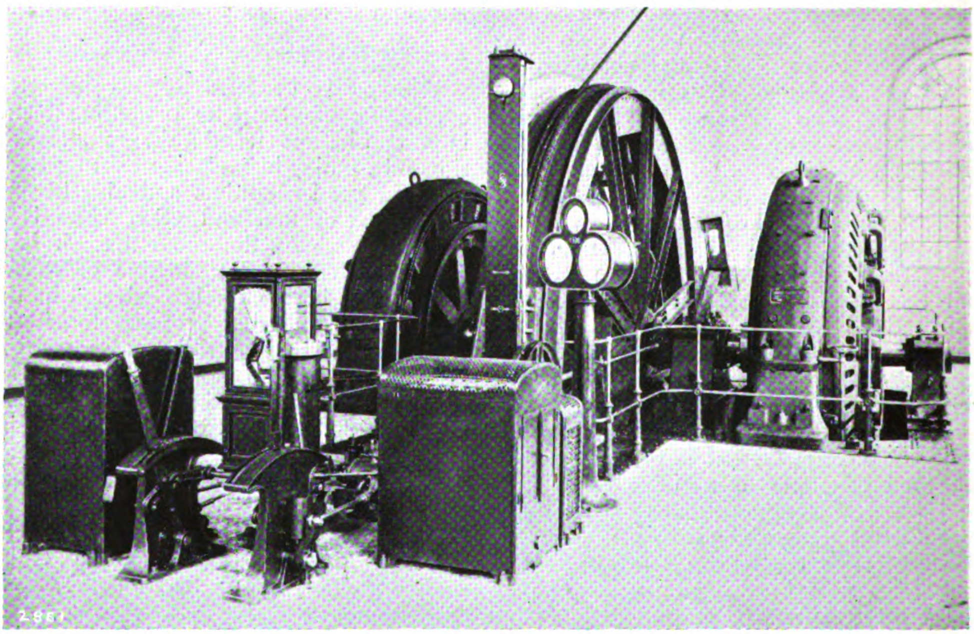


FIG. 3. ELECTRIC WINDING ENGINE (ILGNER SYSTEM).

Many mine managers are said to be of opinion, however, that the saving of coal at the pit's mouth is not important, taking into consideration the quality used for this purpose. The writer cannot accept this opinion, for the following reasons:—

1. Modern machine-worked collieries (coal cutters, drills) produce less slack.

2. Repairs, wages, maintenance, &c., and interest on plant are in part proportional to the steam consumption, and not to coal alone.

3. Slack is being used in improved boilers

to a larger extent outside the mines, and therefore becomes more valuable; it also finds a ready market for the making of patent fuel, &c.

The causes of the bad steam consumption of winding engines are so obvious and well known that it is almost unnecessary to recapitulate them. They are:

1. The frequent, heavy, and short overloads.

2. Condensation losses caused by the stops between winds and other standstills.

3. The variable load, especially with non-balanced ropes.

4. The steam losses in the boilers during standstills.

5. Non economical valve setting, due to the condition of running and starting in any direction and position, also late cut-off.

6. The influence, mostly unfavourable, of the engineman.

The last-named cause especially cannot be too much accentuated, as some of the steam consumption figures obtained have shown. The chief cause of waste is the steam distribution in the cylinders, and this is outside the engineman's reach with electric driving, whilst the manager has the security that losses due to errors of judgment, such as bad stops, too much braking, and overwinding, have small influence on the costs, as with most systems these losses are stored in flywheels or batteries. As to first costs, the writer is of opinion, based on actual experience, that an electrical winding plant, without the generating station, costs the same as a steam winding plant of equal capacity (not counting the overloads possible with the electrical plant).

The savings in size of plant, however, and the capitalised saving in fuel are ample to provide the amount for building the power station, which at the same time is available for all other power purposes.

Choice of System.

Three-phase current will, the writer believes, be more generally employed, because the electric winding plant will, in most cases, form part of an electrical power system, providing power for one or several pits jointly. Thus the power station may be taken as being on the three-phase system, having regard to distances, size of generating units, &c. There are many cases, however, where only electric winding plant is put down with its own generating station at the pit's mouth. In such cases, and also where a direct-current supply exists, direct-current motors will be used, especially as direct-current motors are more easily regulated than three-phase motors.

The amount of energy required by a winding engine in the course of its duty is very variable at different periods of the wind and of the shift. Therefore means must be employed to store and to return energy at proper times. This can be done by a battery, as in traction stations, and by revolving masses by which kinetic energy is paid back at times of heavy load, as in starting, &c. When direct current is used a battery is an excellent means of equalising the amount of energy, and its application permits of the current for the winding engine being taken from the bus-bars of a general direct-current power station, and of installing generating plant, giving the required mean output for the winding engine, whereas, without a battery, the generating plant would have to supply the maximum static energy required for lifting the dead load. Moreover, the battery provides a series of voltages which are used for speed control, thus reducing to a minimum the wasteful functions of the rheostat. The above results can also be obtained by flywheels. The arrangement of including heavy revolving masses in the system is applicable, because the maximum of energy required for the useful load, and the kinetic energy of the revolving parts, are always the same. When using three-phase plant a special flywheel is therefore necessary to convert into continuous current, and to obtain the speed variation for the flywheel. The Ilgner system, which embodies this principle, is now well known, and is being used on the Continent with some hundreds of electric winding plants, while several large engines are on order in this country.

The Westinghouse system is so far different from the Ilgner in that it allows the main motor to be a three-phase motor driven direct from the supply mains, the equalising flywheel set being practically in parallel with the motor, instead of in series, as in the case of the Ilgner system. Both systems have their advantages, the latter being slightly cheaper. A large winding engine of this type has been installed at the Great Western Collieries and is working satisfactorily. Taking the guaranteed figures, which can be easily controlled by the wattmeters, the power consumption in this case

is about 24lb. of steam per useful h.p.-hour in the shaft during twenty-four hours. This is, of course, much less than can be obtained with even the most modern compound-condensing steam winder. As regards first costs, this engine, which is designed for lifting 1400 tons from 1100ft. during eight hours, has cost about £7300, so that the slight excess in first cost over a modern steam winder will be easily repaid in a couple of years. In many cases, however, it will be possible to do without the equalisers by adopting two motors and "series-parallel" control or "Cascade" control, and where a large power station exists with turbine sets, direct three-phase motors can be used. The first cost will then be less than in the case of steam winders, and the whole installation will be of the simplest kind.

As far as the actual construction is concerned, the scope of this article does not permit of entering into details. The direct-coupled slow-speed motor is, of course, the only practical drive for electric main winding, whilst for winches and small underground winders geared motors can be used.

Electric Haulage.

The application of electric power to the various classes of haulages was not one of the first to be introduced in electric mining work, at least not in underground work. The advantages of the electric drive, however, are even more apparent below-ground than with surface plant. The many drawbacks of carrying steam down the shaft, or, worse still, of having boilers underground, are too well known, so that, apart from the much better economy, on the same ground as electric winding, the electric drive scores on the point of convenience, first cost, and easy control of the state of the road. This last point is very important, and is being more and more appreciated by colliery managers. The ammeter on the haulage stand tells the driver and the manager whether their road is still in good condition, or whether it requires straightening and repairing.

Endless-rope haulages, as stated before, add to the general efficiency of the electrical equipment by increasing the load factor. The coupling used is nearly always of the friction clutch type. Endless-rope haulages with several drums on loose sheaves are generally provided with separate friction clutches worked by hand levers. The motor, being continuously under-current, is, of course, rated differently from the main-and-tail haulage motors, although a six hours' rating should also be adopted for the latter, and the starting gear is of much simpler construction. The proper driving of haulage gears is one of the most difficult applications of the electric motor, because of the frequent starting and reversing, large power to be transmitted through gearing, occasional heavy overloads due to bad roads and derailed trucks, difficult conditions of speed control, &c. It is therefore important that the motor should have a reasonable clearance between rotor and stator, which is, of course, limited by the power factor, and be of exceptionally strong construction. The yearly load factor of a main-and-tail haulage is very low, not more than 5 per cent. or 6 per cent., so that the efficiency of the motor is not such a very important point. For large powers, such as are often met with in the main roads underground, flexible transmission is most desirable, and the writer is much in favour of the rope drive wherever possible. The smooth drive, low first cost, and low maintenance costs are so many points in favour, but, of course, lack of room, very wet workings, and shifty floors often limit the use of this drive. In such cases geared motors become a necessity, and it is quite possible to design heavy geared haulages which will work as smoothly and silently as rope drives. Present practice, however, has not quite succeeded yet in attaining this result. The heavy slow-speed haulages in the South Wales collieries are fairly satisfactory as to general efficiency and repairs, but they are noisy and wasteful in gearing. For small sets worm gears or raw-hide pinions may be used, but for larger haulages the spur-wheel drive has been adopted, consisting of steel machine-cut first-motion and moulded second-motion wheels of cast iron (double helical).

Recently single-geared slow-speed motors have been put down, but in the writer's opinion the increased cost of the motor is not sufficiently compensated by the simpler gear. In such cases the writer favours the modern machine-cut double helical gear, which not only permits of fairly high-speed motors, but also runs perfectly noiselessly. The absence of all "backlash" and the smooth, silent running tend to keep down repairs considerably, and fully warrant the slightly increased price of the combined set. The writer's experience is that these gears outlast other types about three times.

The starting and controlling gear is the next important point to be considered, at least as far as main haulages are concerned. If metallic "drum" type controllers are used, special care should be taken to add additional resistance units to allow for "creeping speeds" and also adjustments of a few inches. Oil-immersed controllers must be constructed so as to be fixed and opened horizontally, as head room is not always available, and much time is lost in such cases. The contacts should be renewable, and the contact arms should be of solid construction. They should be protected by isolating switches of the oil break type in order to allow repairs to be effected. The high-tension reversing switch is, in this type of controller, combined with the controlling lever.

For large haulages the number of motor speeds should vary between 20 and 25. The main-and-tail rope speeds vary between 4 miles and 12 miles per hour, in proportion to the power, but the writer is more inclined to adopt the higher speeds wherever possible. Endless-rope haulages should be run at 2½ miles per hour.

Where a water supply is available the writer has recently put down liquid controlling gear of the same type as is used for reversing rolling mills. The repairs and maintenance on this type of controller are much less, there is no danger from explosion or other accidents which may prove fatal in a fiery mine, and the speed control is, of course, much easier and smoother. Their first cost is about equal to the oil-immersed controller. Another important point is the foundations; concrete foundations in collieries, where frequent disturbances of the roofs and floors must be expected, such as in the South Wales collieries, should be replaced by steel or iron girders, so that the complete set is carried on these and no break in the alignment need be feared. For all underground haulage motors the ventilated type is the better, as it is very difficult to construct an explosion-proof enclosed motor of such capacity. The slip-rings should, however, in all cases be completely enclosed with strong covers. Great care should be expended in the connections between resistances, motor, and controller, and these connections should be well protected from outside damage. The bedplates of all underground haulages should be of steel for lightness, and so designed that they can be taken apart and easily erected inbye.

Electric Locomotives.

Electric locomotives are not used to any extent in the collieries of this country, although in some metal mines their use seems to be on the increase. In collieries, the Home Office regulations, the 7ft. height

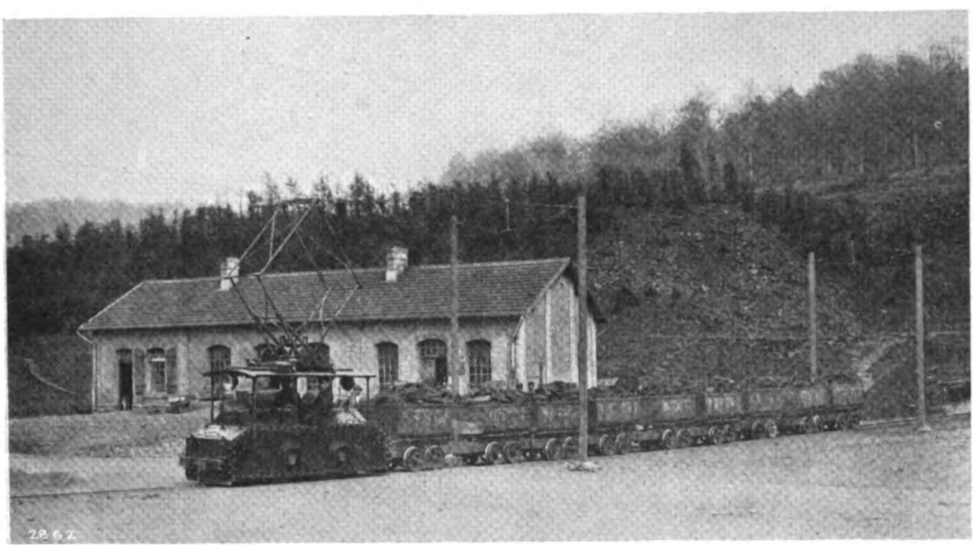


FIG. 4. ELECTRIC MINING LOCOMOTIVE. CONTINUOUS-CURRENT TYPE.

limit, and the danger of bare wires militate against their adoption, although the writer is of opinion that in many cases, for shunting in drifts and for short hauls, their use could easily be extended. Endless-rope haulage is in all cases cheaper, but there are plenty of cases where this system is not possible. Of course, each case must be an adaptation to local circumstances, but for average underground work the writer favours a type built for 30in. gauge, with double-reduction gearing and one alternating-current motor, and with all the axles driven through coupling rods. The equipment is built on the deck, which enables a high centre of gravity to be obtained, and also permits of easy inspection. The current collecting is done by means of one or two bows or a shoe collector, the trolley being impracticable in a mine where the overhead wire is installed on very irregular lines.

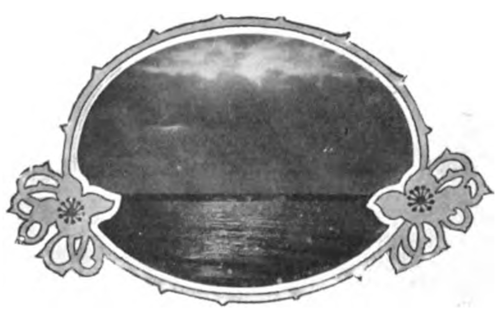
Electric Fans.

The driving of fans was one of the earlier applications of the electric motor, and also one of the most successful from the start. The introduction of high-speed fans of the "Sirocco" type, with the high-speed motor either direct-coupled by means of a flexible coupling or by means of a rope drive to fans of medium speed, forms a unit of excellent efficiency and free from all complications. The savings in buildings, wages, and supervision is well known and need not be further discussed. The lack of flexibility sometimes complained of, and the different requirements during Sundays or at the opening up of a new colliery, can easily be met by installing a small motor as an auxiliary, or duplicate rope pulleys of different diameters. Two motors for the surface fan, one being spare, is always good practice, as so much depends on the fan being ready for work at all times.

It is, however, on the use of auxiliary fans underground that in future the great usefulness of the electric motor will be found, in the same way as for remote pumping. Local districts, varying pressure for different seams, temporary work, sinking work after accidents, &c., are so many special purposes for which electrically driven fans offer a cheap and convenient solution. The motors in these cases are mostly of the variable speed type. Altogether the underground local ventilation system is a new departure, and has only been made possible by means of the electric motor.

High-speed fans of the "Sirocco" type are now being built up to power capacities of 1000h.p., with an output of 1,500,000 cubic feet of air at 6in. water gauge, and with an efficiency of 70 per cent.

(*To be continued.*)



MANCHESTER
Electrical Exhibition.

NOTEWORTHY EXHIBITS.

(Concluded.)

"Igranic" Controllers.

THE object aimed at by the Adams Manufacturing Company, Ltd., in the arrangement of their exhibit was to show for what a large variety of uses their "Igranic" motor controllers have been standardised.

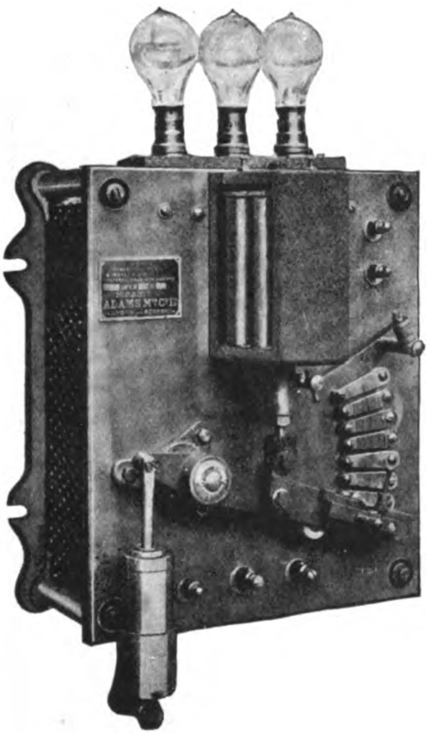


FIG. 1.

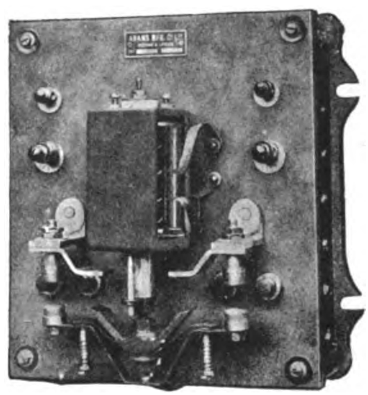


FIG. 2.

The examples included controllers for textile machinery, wood-working machinery, machine tools, cranes, hoists, lifts, capstans, pumps, printing presses, haulage gears, winches, air compressors, hydraulic accumulators, rolling mills and other steel mill machinery, organ-blowers, and, in fact, almost every duty that can be electrically performed, and not only were some of the devices shown actually at work, but nearly all were wired up, so that interested visitors were graphically shown the method of operation. The most noticeable exhibit was a model hydraulic accumulator electrically driven and automatically controlled by the accumulator itself turning a tappet switch at the top and the bottom of its stroke, so that the motor stopped when the container

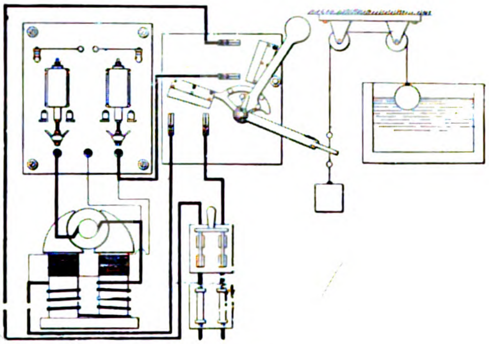


FIG. 3.

became filled, and started again when it had fallen to the lowest pressure position, the services of an attendant being thus entirely dispensed with.

The controlling apparatus is very simple, comprising only a tappet or float switch, a self-acting motor-starter (Fig. 1), and a magnetically-operated main switch (Fig. 2).

A similar combination of apparatus was shown controlling a motor-driven "Gwynne" pump delivering water into an elevated tank, from which, when the tank had been filled, it flowed back into the lower vessel. The arrangement of the parts is diagrammatically illustrated in Fig. 3. This shows very graphically how country houses and the like may be provided with a reliable water supply.

Prominent on the stand was a controller

FIG. 4.

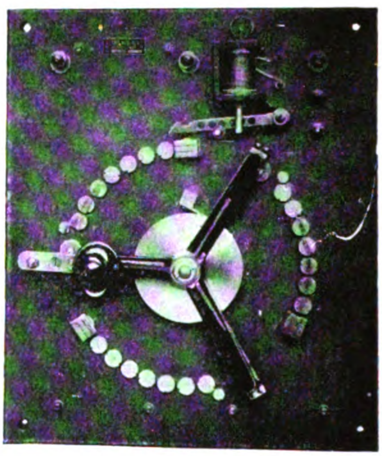


FIG. 5.

for large rotary printing presses such as are used in newspaper offices (see Fig. 4). This is capable of doing everything necessary in the working of those difficult machines, the speeds obtainable ranging from maximum printing speeds down to about 5 per cent. of maximum, and for all these only one handle has to be manipulated.

How quickly new regulations are complied with was shown by the exhibit of alternating-current motor starters with automatic no-volt and over-load releases, an interesting type being as in Fig. 5.

Automatic control is not confined to direct-current apparatus, as is evident by the self-acting three-phase starter illustrated by Fig. 6. In this an oil-immersed solenoid-operated double-pole main switch is provided for the stator circuit, and electrically

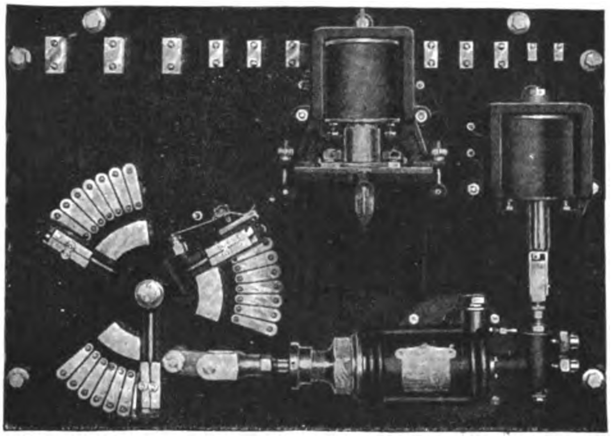


FIG. 6.

interlocked with this is a commutator switch for regulating the resistance in the rotor circuit. To move this switch over its steps an air or hydraulic cylinder is employed the valves of which are automatically controlled by a solenoid. The interlock prevents the stator switch being closed without the starting resistance being in the rotor circuit.

For alternating current motors that can be started by connecting them directly to the supply without the use of starting resistance a solenoid-controlled oil-immersed main switch as in Fig. 7 was exhibited.

In the combined starting and field-regulating switches shown there are not only the usual number of armature starting steps, but also a large number of field-regulating steps, while a perfect mechanical interlock prevents the possibility of any regulating resistance being in the field circuit during the starting operation. These combined starters and regulators were shown with the usual automatic releases, and for cases where it is necessary, in some of the types speed regulation is effected by resistance in series with the armature, either with or without the accompaniment of field regulation. In all these regulators the whole range is secured by the use of only one handle, thus making their operation exceedingly easy and simple.

For reversible variable-speed motors, such as are often directly connected to machine tools, and other reversible machines requiring great speed variation, a reversible combined starting and speed-regulating switch is provided, which can be attached to a splined shaft, and thus operated by a handle which may be moved to any position along the face of the driven machine.

For use in factories where the machines have to be started by employees who have no electrical and very little mechanical knowledge an absolutely fool-proof and practically indestructible starting switch (Fig. 8) was shown. This is entirely ironclad, even the

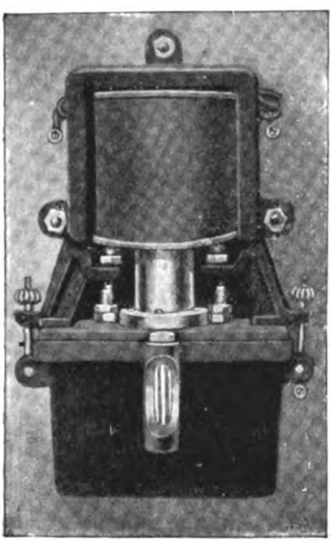


FIG. 7.

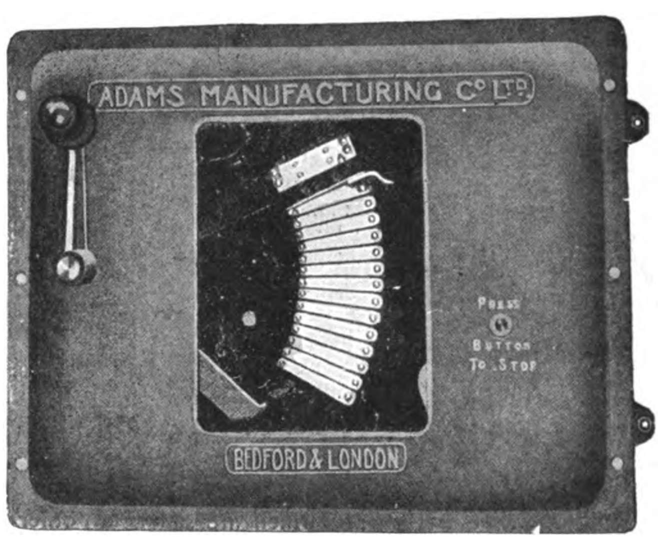


FIG. 8.

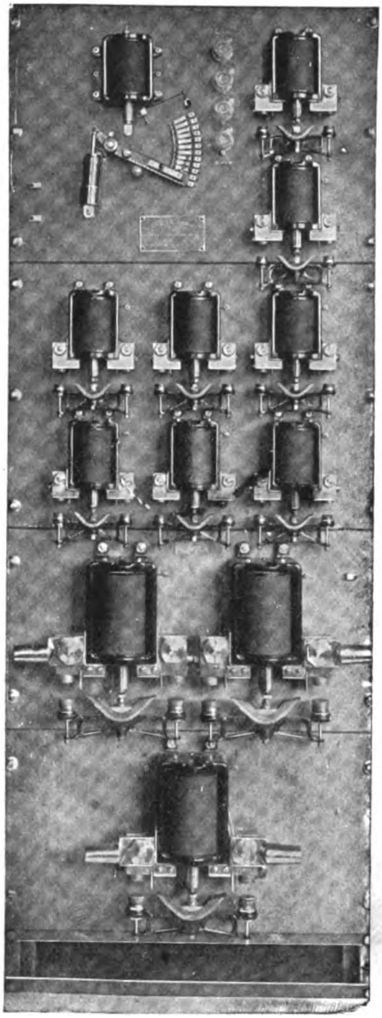


Fig. 9.

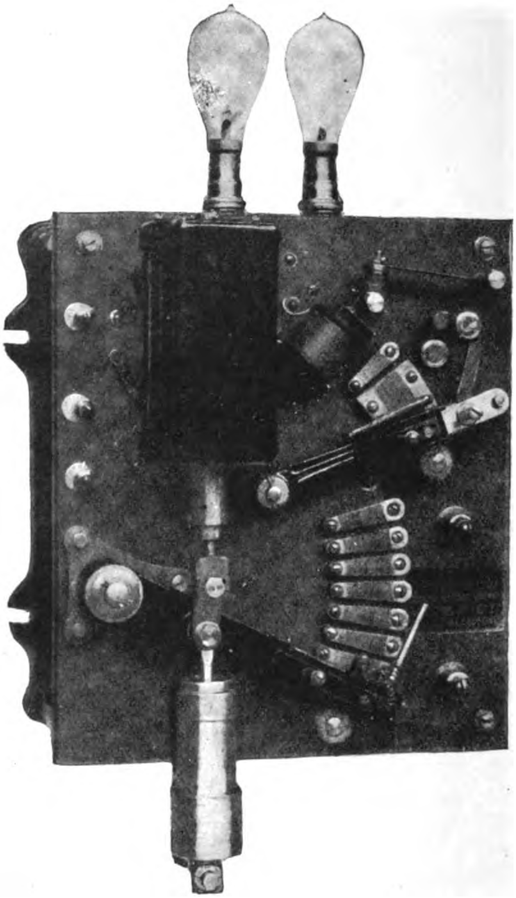


Fig. 10.

glass panel being replaced by iron when desired, and it is so constructed that the most ignorant, careless, or malicious operator cannot damage the motor by its use; at the same time, it is so simple and easy to use that it makes no demand upon the patience of the operator, as do worm-geared or ratchet starters or others that seek to prevent damage by compelling slow movement.

The fan controllers exhibited appear to have attained very near the limit of what is possible in the direction of compactness and neatness.

Other exhibits included field regulators with innumerable steps, and which are said to combine cool running with durability; push-button control for all sorts of machines, from printing presses to passenger lifts; a contactor switch that is magnetically operated, and is designed to frequently break circuits carrying thousands of amperes; master controllers for machines absorbing hundreds of horse-power, of which Fig. 9 is an example; and not least interesting is the new automatic starting switch patented by Mr. Frank Broadbent (Fig. 10), which has already proved its usefulness and reliability in actual use, but had not previously been publicly exhibited.

Of course, there is the usual array of what may be called everyday manually-operated switches with all kinds of safety features, including iron covers designed to prevent damage from shock, water, explosion, or any other cause. The abiding impression left by this exhibit is that this enterprising firm

had indeed shown to what extent the expense of attendance can be saved by making electrical machinery self-acting, and how far the effects of human errors of carelessness and forgetfulness can be eliminated by the use of modern controlling devices.

Babcock & Wilcox, Ltd.

THE exhibit of this renowned firm consisted of a series of models illustrating the construction and action of their steam-raising specialities. There is no need here to describe the boiler itself; practically every engineer is familiar with its general details. The illustration Fig. 1 shows the internal arrangement of a boiler fitted with the firm's superheater and stoker. The use of superheated steam ensures a saving of some ten to fifteen per cent. in the steam consumption of even a modern highly economical engine; whilst, with older and more wasteful engines the saving is considerably greater. The B. & W. superheater consists of a number of solid-drawn steel tubes, bent into a U form, and expanded at each end into wrought-steel boxes or manifolds. The steam from the boiler, entering the upper manifold box, divides amongst the tubes, and during its passage through them becomes superheated, or raised to a higher temperature than previously, the pressure remaining unaltered.

When steam is being raised from a cold boiler, an arrangement is provided for flooding the superheater. This consists of a connection with the water space of the boiler and two cocks. By opening the larger of these, water is admitted to the superheater, and fills it to the boiler water-level. Any steam formed whilst the superheater is flooded is returned to the boiler drum. When steam is raised to working pressure, and before opening out the boiler on to the steam range, the large cock is closed and the small one opened, and the water flooding the superheater is then drained away, a sight glass being provided to show when the draining is completed.

The Babcock and Wilcox patent chain grate stoker is designed for the efficient and smokeless combustion of semi-bituminous fuel. The grate consists of an endless chain of short interlocking cast-iron grate bars, linked together, running on rollers, and driven by a revolving drum at the front end of the stoker; the necessary power being transmitted through a link chain and sprocket wheels, from a shaft arranged either overhead or underground.

The starting or stopping of the stoker, or the variation of speed, is effected through a patent gear-box, which provides for varying speeds.

The coal is fed over the whole width of the grate, the depth of the fire being regulated by the adjustment of the vertically lifting fire door. The feed of the coal is slow, and the gases evolved from the fresh fuel pass underneath a highly-heated fire-brick arch and over the incandescent coal, and complete their combustion before coming into contact with the boiler-heating surface.

The fuel is gradually consumed as the grate travels on, and, when the dumping bars are reached, only ash and clinker remain, which fall into a receiving pit provided with a hinged bottom, which is opened as and when required to allow of the clinker being removed.

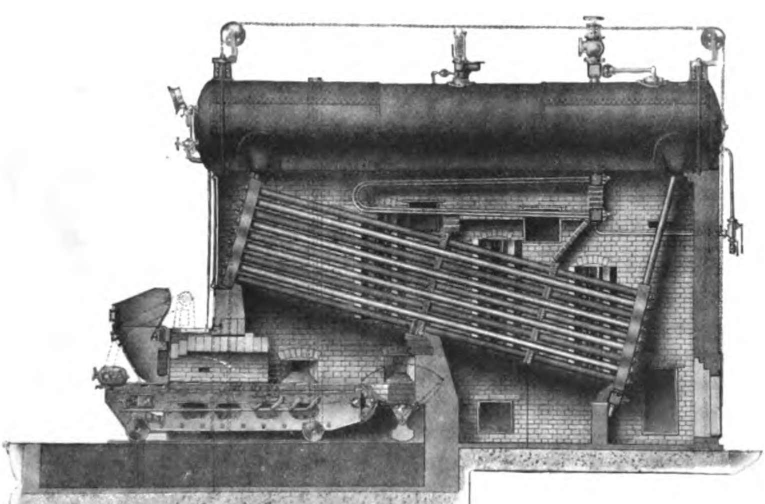


FIG. 1. BABCOCK & WILCOX BOILER FITTED WITH SUPERHEATER AND CHAIN GRATE STOKER.

The depth of the

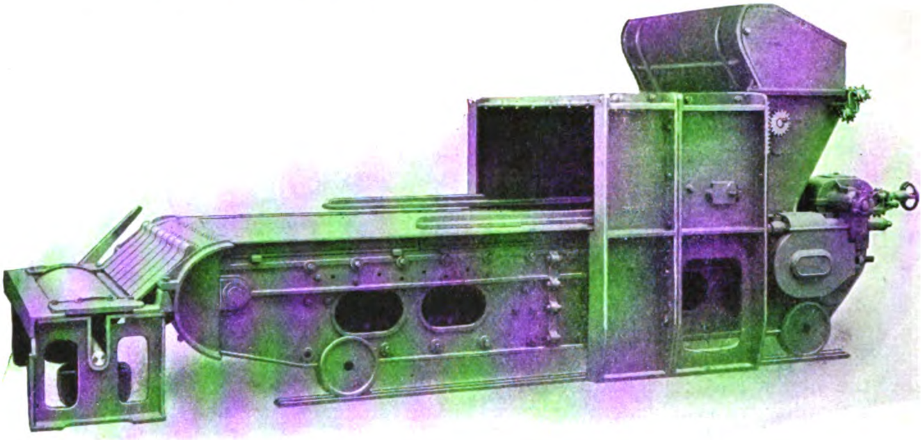


FIG. 2. BACK VIEW OF BABCOCK & WILCOX CHAIN GRATE STOKER.

fuel and the speed of the grate can be adjusted in a minute to suit the conditions of draught available, the class of coal to be burned, and the evaporation required.

In case of need the stoker can also be worked by hand, by a crank placed on the end of the worm shaft. Should the working of the stoker from any cause be temporarily affected, hand firing may be resorted to.

The water softener, Lassen and Hjort system, of which a model was exhibited, has been designed for the purpose of removing, by chemical means, the scale-forming matter from water prior to its use, thereby preventing damage to boilers, &c., from the accumulation of incrustation, at the same time effecting a large saving in fuel consumption by keeping all parts of the boiler heating surface in a clean and thoroughly efficient condition. The water softener is extremely simple in its working, and the arrangement for mixing the chemical reagents with the water ensures most reliable results. The apparatus works quite automatically, the supply of water to the softener being regulated by a float valve, and the chemicals being added by a patent automatic measurer.

If a supply of exhaust steam is available it can be utilised for heating the water, thereby shortening the time of treatment, enabling a smaller apparatus to be used for a given quantity of water softened, and making the plant a combined water softener and feed-water heater. If no steam is available, however, water can be equally treated in the cold.

Other exhibits included specimens of the firm's work in the way of steam piping, and an interesting collection of photographs of boiler installations and literature dealing with coal-conveyor, electric crane and structural steel work installations, &c.

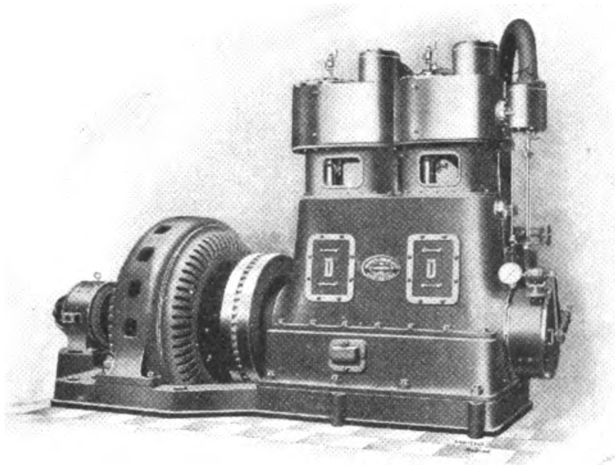
High-speed Engines.

THE exhibit of Browett, Lindley, & Co., Ltd., was in the form of one of their latest standard, enclosed, forced-lubrication, two-crank, compound-vertical, double-acting steam engines, having piston valves to both cylinders.

The governor of this type of engine is of the centrifugal type, fixed to the crankshaft, and acting direct on the throttle valve. There is also worked in conjunction with this governor an automatic expansion gear controlling the cut-off in the high-pressure cylinder.

The engine is of very massive construction, with all motion work, including the governor, entirely enclosed within the frame and base, and all working surfaces so enclosed are lubricated by oil under pressure from a valveless pump placed in an easily accessible position in the lower part of the bed and connected from one of the eccentrics. All bearings are easily adjustable, and there is no complicated gear about the engine to get out of order. The engine is as simple as can be manufactured to give great economy and high efficiency.

Owing to the forced-oil system being used, very little attention is required to run these



Browett-Lindley Electric Generating Set.

engines beyond occasionally filling up the cylinder lubricator. The particular engine shown at the Exhibition is capable of developing 250kw. as a normal load, working either condensing or non-condensing, running at 375r.p m., and working with a steam pressure of 120-140lb. per square inch. It was direct-coupled to a dynamo by the Lancashire Dynamo and Motor Company of their standard type.

This engine is similar to many which the makers have supplied with great success for electric light and power to a large number of the leading corporations, ironworks, collieries, and other industrial concerns throughout the British Isles and abroad, and is made in standard sizes from 20kw. up to 500kw. Messrs. Browett, Lindley, & Co. also make triple-expansion engines and three-crank compound engines in three sizes from 150kw. to 1500kw.

Substation Switchboards.

The leading feature of the exhibits of Ferranti, Ltd., consisted of the high-tension and low-tension switchboards of the Manchester Corporation exhibition sub-station adjoining the stand of the firm and controlling the entire electrical supply of the exhibition. These switchboards were typical of the latest up-to-date design of switchgear for controlling converting machinery, for taking a three-phase supply at 6600 volts, and delivering direct current at 400 volts to 500 volts. The extra high-tension switch-gear is of the compartmental design, *i.e*, it consists of vertical columns of reinforced concrete cubicles in which the details of the high-tension gear are placed and isolated from each other. The compartments are closed in front by $\frac{1}{8}$in. planished steel sheets, and at the back by iron doors. The switches are operated by handles projecting through the planished steel sheets in front of the switchboard. Thus the whole arrangement is eminently safe against accidental contact and fire risks.

The switchboard at the exhibition consisted of: two feeder panels; one motor converter panel; one rotary converter panel; one motor generator panel; and one transformer panel.

All the switches were of the automatic oil-break type, those on the feeder panels being fitted with no-volt release attachments, while the converter and transformer switches operated in conjunction with Ferranti special time-limit relays. The latter switches are also provided with additional contacts so that the high-tension circuit of the converter is initially closed through a water resistance, for the purpose of avoiding sudden electrostatic potential strains being thrown upon the winding of the machinery at the instant of closing the circuit.

Provision is made on these boards for entirely cutting off any panel from the bus-bars, and thus rendering any particular panel dead at will.

The low-tension board of the installation was of the flat-back panel type, and on it were shown fine examples of circuit breakers, switches, fuses, and instruments of Messrs. Ferranti's manufacture.

On the adjoining stand Messrs. Ferranti were further exhibiting a number of interesting detail apparatus; the principal items being as follows:—

A group of all classes of supply meters, including house-service for alternating and direct current supply, switchboard type, two-rate type, three-phase, pre-payment, &c., &c.

Switchboard and portable type instruments,

THE FERRANTI HIGH-TENSION SWITCHBOARD.

including power factor indicators, indicating wattmeters, frequency indicators, relays, leakage indicators, and other highly specialised products.

Various sizes and types of starters for direct-current motors. Component details of these starters were displayed, illustrating the fundamental principles involved, which are radically different from other starters on the market, being practically indestructible, having no wire coils or spirals to short-circuit and burn out, &c., &c.

Electrically and mechanically operated switches were to be seen in operation. These switches are constructed on the lines of Messrs. Ferranti's patents, and are used by most of the leading corporations of this country, including those of Manchester, Glasgow, Leeds, London County Council, &c.

THE STAND OF FERRANTI, LTD.

A further exhibit consisted of a small complete low-tension power switchboard which Messrs. Ferranti have built for installation in their own power station at their works at Hollinwood.

Boilers and Fittings.

THE exhibit of Galloways, Ltd., consisted of boiler parts, models, and steam boiler fittings. These included a patent flue for a 7ft. diameter cylindrical internally fired boiler, containing fifteen patent cone tubes. This flue, which is the distinguishing characteristic of the Galloway boiler, is so well proportioned and stayed by the tubes, that it is undoubtedly the strongest part of the boiler; the further advantages obtained by the insertion of cone tubes in the flues of boilers are, increased heating surface and thorough circulation of the water. There was also shown a front end plate for a five-flued boiler with angle ring for connection to shell and the first ring of each of the five flues; the end plate exhibited was fitted with a double set of water gauges and protectors, a 9in. high-pressure steam gauge and syphon, and a 2½in. high-pressure check feed valve with tee piece. This boiler has been specially designed in order to utilize the waste gases from coke ovens: it possesses large and efficient heating surfaces, with full facilities for cleaning and examination, and has been adopted by many colliery proprietors.

The two patent wrought-steel steam superheaters exhibited each contained 29 tubes, one having the cover bolted on complete, and the other with the cover loose. The special feature of this superheater is that it is built entirely of Siemens-Martin mild steel, and as a structure is quite as strong as any portion of a steam boiler.

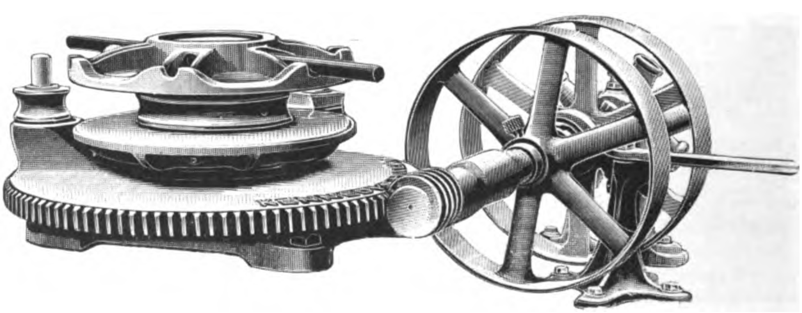
The steam boiler fittings consisted of six "Perfect" junction valves, each fitted with Galloways' improved arrangement for rotating the valve on its seat whilst under pressure; two "Perfect" feed valves with outside crossbar and pillars of wrought steel; two gun-metal parallel slide blow-off taps, fitted with locking guard, and suitable for high pressure; and two patent high steam and low water safety valves, the special features of which are the simplicity and adaptability of the valve for examination without emptying the boiler of water, breaking any pressure joint, or disconnecting internal parts.

Tube-Bending Machines.

THE "Kennedy" patent bending machines, though simple in construction, are the most universal benders on the market, bending cold and unloaded, not only tubes, but almost any section of metal within their capacity, and to a much smaller radius than on any other machine. They are in considerable use by electrical contractors for the bending of electric wiring conduits and ducts, and, indeed, are generally applied where tubes, bars, angles, channels, and strips are worked with.

The larger machines can be arranged to drive either by hand or belt power as required. Being self-contained, they can be readily moved from place to place and taken to their work, instead of bringing the work to them, and at the same time frequently save the necessity of a smith's hearth. Duplicate bends made on these machines are always alike, and can be reproduced at any time without trouble. Any number of bends in any direction can be made in a single length of tube, thus doing away with a large number of expensive fittings, avoiding leaky joints, and producing a much neater job.

The machine illustrated is of the No. 3 size, arranged for power drive. It will bend copper and brass tubing up to 2in. external diameter; standard iron tubing up to 2in. internal diameter, with radii from 3½in. to 7in. There are in all eight standard types and sizes available.



THE KENNEDY BENDING MACHINE, ARRANGED FOR POWER DRIVE.

Electro-pneumatic Hammers.

MESSRS. B. & S. MASSEY exhibited a 3cwt. friction drop stamp and also one of their pneumatic-power hammers of the 3cwt. size as arranged for driving by electric motor. The electric drive of these hammers may be either by direct or alternate current, the motor being mounted on a rigid bracket bolted to the main standard of the hammer. The drive is by means of a raw-hide pinion on the motor shaft gearing into machine-cut teeth on the periphery of the hammer fly-wheel.

This arrangement is very simple and compact, and is quite satisfactory when the anvil-block is a separate piece from the standard, resting independently on the foundation, as is the case in all the Massey hammers excepting the smallest sizes. There is then no direct connecton between the anvil-block and the motor, and it is found that the vibration is not more than a first-class substantial motor will stand without harm.

The system of driving individual machines by separate motors instead of through line shafts and belts is one which is forcing itself more and more on the attention of engineers, and close study of the subject in reference to power hammers has shown that there are very great advantages to be gained by its adoption. The important feature connected with the individual electric driving of hammers is that power is only taken while the hammers are actually working, and in proportion to the work done; whereas when hammers are

driven by belt it is necessary to keep heavy shafting and belts running continuously, although the hammers themselves are only required intermittently.

In order to give an idea of the extra power thus used, Messrs. Massey have published the results of two very careful tests with a 7cwt. pneumatic power hammer which was run on two consecutive days for a period of three hours. In the first test the hammer was driven by a belt through a 3in. line shaft, 29ft. long, the shaft being driven by a 35b.h.p. motor. When not required the hammer was stopped, but the shaft was kept running continuously.

Accurate readings were taken on an electricity meter to determine the energy consumed for each job, and also the energy taken up in driving the shaft alone.

The forgings made included both heavy and light work, and represented as nearly as possible a typical three hours' production.

The second test was an exact repetition of the first, with the exception that the hammer was driven by a separate electric motor.

Comparing the results of the two tests, it was found that the energy taken by the hammer itself was very nearly the same in each case, viz., 6.25 and 6.87 Board of Trade units respectively, the difference being due to accidental circumstances only.

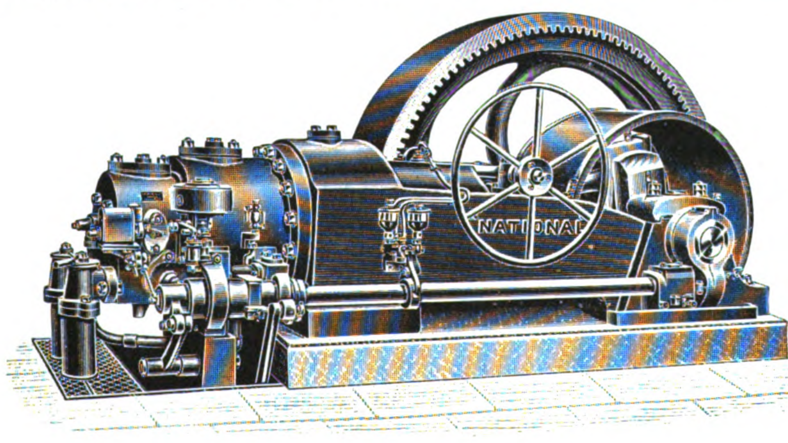
A certain amount of current was of course lost in the motors, and this was considerably greater in the case of the belt drive, because the motor was running for a longer period and at a lower average load, and therefore the efficiency was less.

The energy used in driving the shaft is very large. In this instance, in which one hammer only was driven from the shaft, it was nearly one and a half times the current used in the hammer itself. This ratio would of course have been proportionately reduced if two or three hammers had been driven from the shaft, instead of only one, but even under the best conditions of belt driving the loss of power due to running heavy shafting and belts continuously is a large item, and such a loss is entirely absent in the case of direct electric driving.

The direct electric drive for power hammers has further advantages such as the following: Hammers with motors coupled to them can be placed anywhere, without reference to the position of engines, shafting, &c., and can thus often be used to greater advantage than when the choice of position is restricted to a place where a belt drive is convenient. The entire absence of belts enables cranes to be used with much greater freedom above and around the hammers. Each hammer, being complete in itself, and entirely independent of other machinery, can be used to much greater advantage in case of overtime, night work, or repair work.

Gas-electric Plant.

THE National Gas Engine Company, Ltd., exhibited two types of their well-known gas-electric generating sets. One of these consists of a new type of engine, recently introduced on the market and fitted with the firm's latest improvements in the way of ring lubrication on the main bearings,



THE NEW TYPE OF NATIONAL GAS ENGINE.

throttle governing, electric ignition, and compressed-air starting. At the exhibition the set was shown in actual service under load, the gas supply being drawn from a National "Gold Medal" type suction-producer gas plant. In all engines working with producer gas great advantages are secured by the use of electric ignition in place of the ordinary tube ignition. It is well known that with small self-contained producer plants great difficulty is experienced in maintaining absolute uniformity in the quality of the gas made, and this fluctuation in the quality sometimes causes difficulties in the proper firing of the charge in the engine cylinder when ordinary tube ignition is used. It is to overcome such difficulties that the adoption of the electric ignition is specially recommended. With the National engines the electric current for the firing spark is obtained from a high-class magneto machine with stationary armature and oscillating shutter. The magneto machine and sparking gear are actuated from the side shaft by a lever and cam. The contact breaker in the cylinder is arranged in a removable plug which can be easily withdrawn for inspection and cleaning. The makers state that there are many hundreds of their engines fitted with this type of electric ignition in successful operation at the present time.

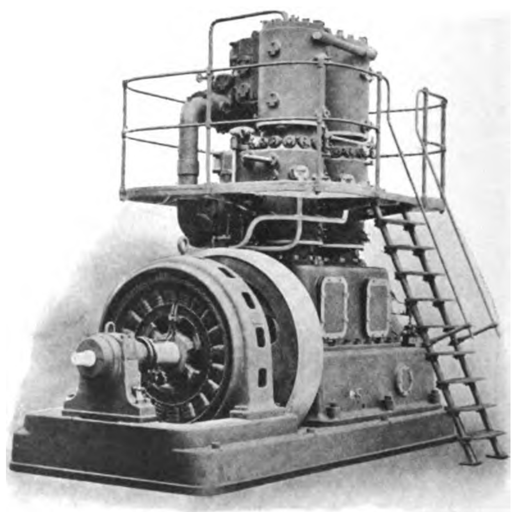
The other gas-electric generator exhibited consisted of a combined electric lighting set made up of an "ME" type engine working on the town's gas supply, and direct-coupled to a slow-speed dynamo. The set shown is of the size suitable for electric lighting systems of about sixty to eighty 16c.p. lamps; they are standardised for capacities up to 3000 lights.

The particular advantages of gas-electric generation are well known, and the operating exhibit of the National Gas Engine Company attracted wide attention.

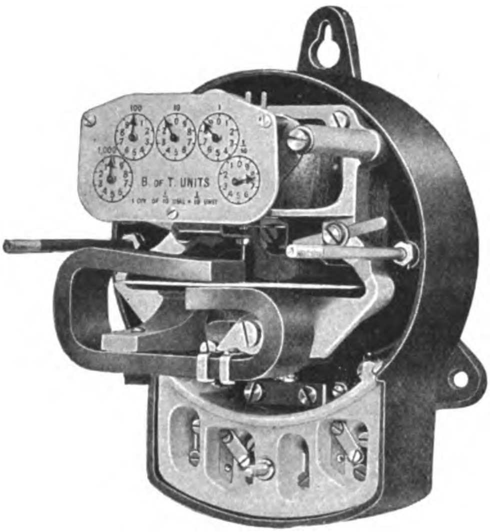
Westinghouse Exhibits.

700kw. Rotary Converter.

The large space occupied by the British Westinghouse Company was used to excellent purpose in indicating the extreme variety of the company's products, ranging from the heaviest classes of dynamo-electric machines and engines to switchboard apparatus and instruments. Of the heavy exhibits mention should be made of the 50-period rotary converter shown running under the usual conditions obtaining in sub-stations and supplying power and lighting. The machine has a normal output of 700kw. and is rated to take a 50 per cent. overload for two hours and 100 per cent. overload for short intervals. The direct-current voltage can be varied in small steps from 400 volts to 550 volts by means of an alternating-current booster placed between the collector ends and the armature. The voltage is varied by changing the excitation of this booster, and the power-factor can be varied independently of the voltage by adjusting the excitation of the main field magnet. Thus it is possible to run all day at a leading power-factor and so compensate for lagging current taken by other apparatus. The machine, which is of the six-phase type fitted with heavy amortisseurs, illustrates the great stability of the 50 period rotary converter when properly designed and its suitability in every respect for general power and lighting work. Without the booster the rotary will give a range of voltage from 440 to 480 volts and from 500 to 575 volts; thus, for many systems the booster would be unnecessary. The combined efficiency of the rotary and its transformer is 95¼ per cent. full load, 93½ per cent. half-load, and 89 per cent. quarter-load The addition of the booster reduces the efficiency by two-thirds of one per cent. at full load. One feature worthy of note is the small size and small floor space occupied by the machine



Westinghouse Gas Engine.



WESTINGHOUSE A.C. SUPPLY METER WITH COVER REMOVED.

and its transformer. This is specially remarkable in view of its great overload capacity.

The rotary is started by means of a starting motor and synchronised on the high-tension side of the transformer. As the cables pass direct from the transformer to the rotary the switchgear is identical with that usually employed with motor generators.

Vertical Tandem Gas Engine.

The Westinghouse vertical tandem gas engine exhibited is said to represent the very latest practice in the gas-engine world. The engine is of the enclosed type, having three pairs of cylinders placed over three cranks, and the one shown has a normal rating of 150b.h.p. Forced lubrication is adopted throughout and operated by valveless pumps, which are fitted in duplicate. The oil, before passing the engine parts, is drawn through filters the sieves of which are arranged so that they can be withdrawn for cleaning whilst the engine is in motion.

This type of engine has been designed with a special consideration for simplicity and accessibility of the parts, and it was to be noticed that by removing the top cover and dropping the bottom half of the connecting rod bearing, the connecting rod, together with the pistons and the internal cover, could all be removed by an overhead crane in a very short space of time. It was also of special interest to notice that in this type of engine no water cooling is used in any of the moving parts.

All the valves are actuated by cams and straight push rods working directly on short bell crank levers fitted on the covers. Any trip gear and unnecessary wearing parts are avoided. The engine is controlled by a governor fitted on the end of the shaft which operates directly on throttle valves.

From the large list of orders displayed on the stand, it was shown that engines of this type are being used in sizes from 100b.h.p. to 1000b.h.p. direct-coupled to all the standard makes of generators on the market, and operating in connection with almost every branch of industry. Perfect operation in parallel is guaranteed with these engines, in connection with alternator work of every description.

Automatic Transformer Cut-out.

There are two general methods for reducing transformer iron losses at times of low load—the series system and the parallel system. In each case a small transformer is used in connection with a large one.

In the parallel system, when the load on the circuit falls below a certain predetermined value the large transformer is disconnected on both primary and secondary sides and the small transformer is left to carry the load. When the load increases above a certain value the large transformer is switched into circuit. Thus at times of

WESTINGHOUSE METER COMPLETE.

light load the comparatively heavy iron loss of the large transformer is avoided.

In the series system the large and the small transformer are connected in series. When the load on the system exceeds a certain predetermined value the small transformer is short-circuited, the whole of the load being carried by the large transformer. When the load drops below a certain value the small transformer is open-circuited, and thus acts in series with the large transformer. Since the impedance of the small transformer is greater than that of the large one, almost the whole of the voltage of the circuit appears across the small transformer, and consequently the iron loss on the large transformer is very greatly reduced.

A number of modifications of the two systems are possible. This is specially true with reference to the parallel system, where the windings of a single transformer may be connected in parallel for heavy loads and in series for light loads, or in the case of three-phase working may be changed from delta to star, &c. The series system is the invention of Mr. C. F. Scott.

The Westinghouse automatic transformer cut-out is a device which may be used for short-circuiting the small transformer in the series system or for cutting out the large transformer in the parallel system. It consists essentially of an upright arm carrying a primary and a secondary switch. The arm is operated by means of an A.C. solenoid provided with two windings, one for opening and the other for closing the switches. The coils are energized from the secondary side of the transformer, and are so arranged that immediately the switch is opened or closed the coils are out of circuit. The coils are controlled by means of a relay in series with the main circuit. When the current in this circuit exceeds a certain value the relay completes the circuit through the closing coil and the switch is closed. When the load falls below a predetermined value the relay completes the circuit through the opening coil and the switch is opened.

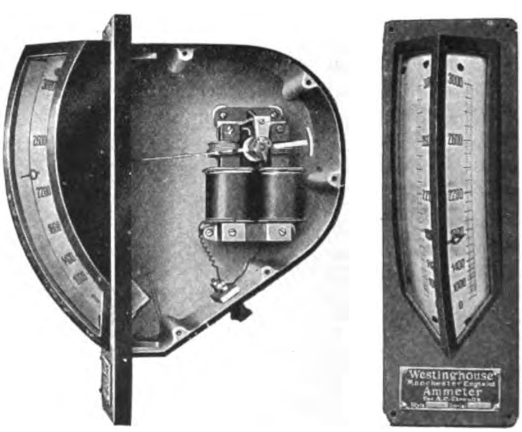
In the event of the switch sticking and refusing to close, a fuse is blown. This fuse supports a weight upon a lever arm. When the weight is released, the lever arm is depressed and the switch closed. This arrangement precludes any possibility of the small transformer being burnt out on account of any difficulty occurring in the operation of the switch. An ingenious arrangement has been devised by means of which the standard switch may be used on a three-wire distribution circuit for either the series or parallel system. A number of novel features are embodied in the design and construction of the switch, which attracted a good deal of attention from visiting engineers.

Switchboards and Switchgear.

A very large variety of Westinghouse work in connection with switchboards and details was shown. The following summary of the leading exhibits of this class are worthy of mention :

A standard direct-current switchboard panel, copper finish, with enamel-finished back, and fitted with one 1000amp. automatic overload, loose handle, type C circuit-breaker; one 1000amp. direct-current type D ammeter, copper finish, rear connections; one 1000amp. standard ammeter shunt; one 100amp. 600-volt type D switch. This switchboard consists of three white Sicilian marble slabs, having the new white enamel finish at back. The rear connections are of bare copper strap.

An alternating-current switchboard with the following instruments mounted on it :—One alternating-current type F ammeter, 80amp. 50-periods, nickel finish; one alternating-current type F voltmeter, 7500 volts maximum, nickel finish; one alternating-current type F wattmeter, nickel finish (the calibration of this wattmeter is 80-5amp. series, 5000-100 volts shunt, 50-period, three phase); a three phase power factor meter, nickel finish, 50-period, 80amp. 5000 volts; a polyphase, type A, inverse time limit relay, nickel finish, to operate off 6amp., 240 volts,



WESTINGHOUSE SWITCHBOARD INSTRUMENTS.

50-period, single-phase circuit, without transformers; a 300amp., 6600 volt, 3-pole type B oil circuit breaker, nickel finish, with two alternating-current trip coils, 5amp.; two brackets, each containing a 16c.p. 240 volt tungsten lamp. This switchboard is also built upon three white Sicilian marble slabs, with white enamel finish at back.

The above two switchboards were shown in service on the exhibit for distributing power. Other switchgear specimens exhibited include a standard iron-clad unit type panel, mounted with a direct-current type CI ammeter, 100amp., copper finish; a 100-amp. E.P. unit type switchbox; a 100amp. D.P. unit type fuse box; and a direct-current motor starter, suitable for 25h.p. 220-volt shunt-wound motor, and fitted with renewable contacts, maximum and minimum releases, and dust-proof cover.

An inverted type colliery switch pillar, designed for use in mines and collieries, and in exposed situations in shipyards and works generally. It is especially suitable for substation installations in collieries or works in which it is desired to utilise old and inexpensive buildings to house the switchgear.

A specimen panel of flame-proof switchgear was exhibited. This consists of a flame-tight and explosion-proof switch and fuse boxes, mounted on channel iron frame, and surmounted by an ammeter; the whole forms a convenient combination for the control of power or lighting circuits in fiery mines.

The Westinghouse type H4 totally enclosed oil switch, combined with instruments for pressures up to 3300 volts, is weatherproof, gas-proof, and dust-proof, and is fitted with glands or junction boxes which can be adapted to any type of cable. The switch itself is loose-handled and fitted with overload automatic device, and for one, two, or three poles; when an overload attachment is required, in not more than two phases, the switch can be fitted with a no-volt device up to 600 volts, and above in certain combinations. A special feature of this switch is that the oil tank is detachable without dismantling the switch.

The several examples of Westinghouse controllers shown include the following: a type HO, with rope wheel, 10b.h.p., for operation from floor level (this can also be supplied with an automatic return to the "off" position); a type H1 controller for hoisting motors, 25b.h.p., with lever handle, which operates in accordance with the direction of the load (this can also be fitted vertically for derricking, cross-traversing, &c.; this type may be arranged to automatically return to the "off" position); a type H2, 40 b.h.p., with standard crank handle; a type H3, 55b.h.p., with handwheel; a type HO and H1, with universal handle, for operating two motors with one handle (No. 1, horizontal handle suitable for hoist and cross or traverse motion: No. 2, vertical handle, suitable for derricking and cross traversing and long traversing); and a star-delta controller, type OB2, for induction motors. This can be arranged for the following duties:—Type OB2A for star-delta starter for three-phase squirrel-cage motors, type OB2B for series parallel starter for two-phase squirrel-cage motors, type OB2C for two-speed controller for three-phase squirrel-cage motors, OB2D for three-speed controller for three-phase squirrel-cage motors.

WESTINGHOUSE FLAME LAMP.

There were also exhibited many forms of motor starters, metallic and liquid types, unit resistances, brake-solenoids, &c., too numerous to mention in detail.

Supply Meters.

Two new types of Westinghouse meters were shown. Type O direct-current amperehour meter is extremely simple, and is especially suitable for small consumers. It is of the shunted type, in which a small motor is driven by the drop across resistance, through which the main current flows, the speed of the motor armature being proportional to the drop across this resistance. The commutator is of small dimensions, thus reducing friction and wear from this source to a minimum. The motor is very compact, its over-all dimensions being 5in. wide, 6½in. long, by 5in. deep.

For two-wire circuits of frequencies of 40 periods and more the type N single-phase watt-hour meter has been introduced. This

new instrument is small and very compact, of simple and strong construction, and is specially adapted for circuits in which the pressure varies. The speed is slow, and the moving element extremely light. The ratio of the torque to the weight of moving element is much higher than in any other motor. An accuracy of within 2 per cent from one-twentieth of full load up to 25 per cent overload is guaranteed for one year.

Arc Lamps.

New types of Westinghouse flame and enclosed arc lamps were a prominent feature of the exhibit. The flame arc lamp manufactured under the Westinghouse-Bremer patents is simple in construction, and is said to have fewer working parts than any other lamp on the market. It is made for burning on either continuous or alternating current circuits for ten to forty hours' continuous burning without re-carboning, and is standardized in 6amp. to 13amp. sizes. The three types made are single, double-carbon, and magazine. Many hundreds of these lamps are in use giving complete satisfaction. They were shown lighting the maker's stand and also on the front of the exhibition building.

The enclosed arc lamps are supplied for either continuous or alternating-current circuits. They are for either indoor or outdoor use, and will be found suitable for those positions where the extremely powerful light of flame lamps is not required. A common source of trouble with many lamps of this "clutch" type is sparking at the clutch; this trouble is obviated in these lamps by making contact with the carbon through their holders instead of through the clutch. The working parts have been reduced to a minimum and are all readily accessible. The lamp capacities are: burning hours, with one trim of carbons, 60 to 80, according to type; current, 3amp. to 7amp.

Electro-textile Plant.

ALTHOUGH stand No. 173 was ostensibly for the purpose of showing the practical application of electrical plant made by J. P. Hall & Co., Ltd., of Oldham, of

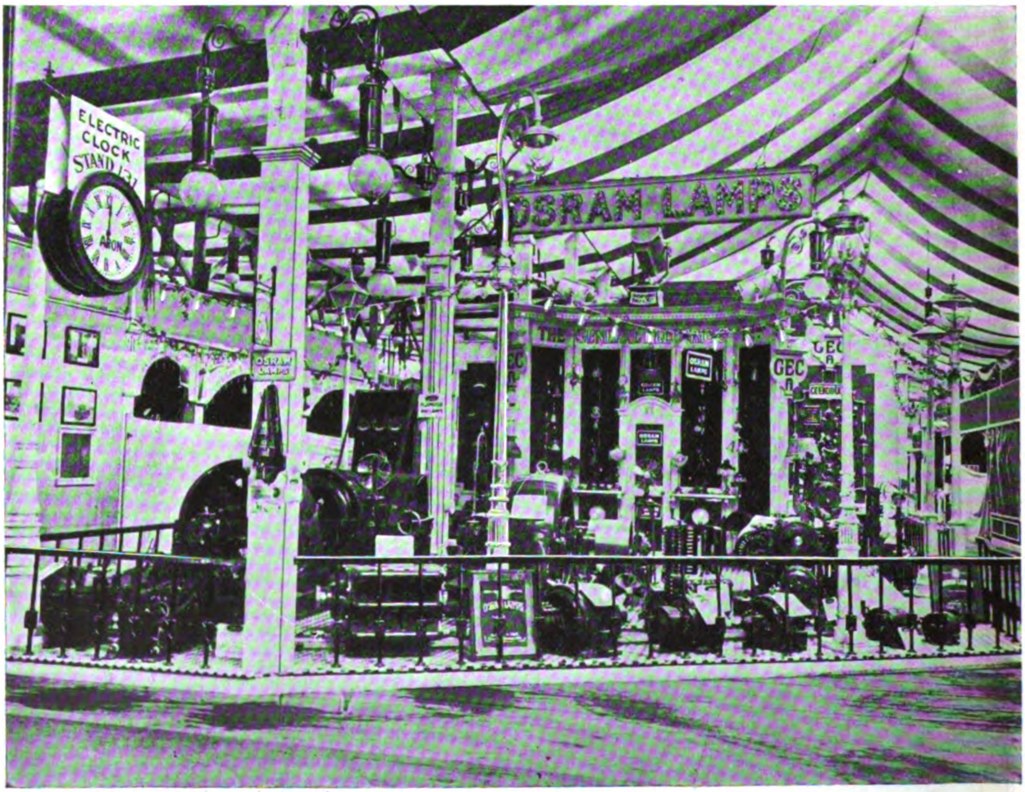


EXHIBIT OF THE GENERAL ELECTRIC CO., LTD., OF WHICH PARTICULARS WERE GIVEN IN THE OCTOBER NUMBER OF "THE ELECTRICAL MAGAZINE."

extreme interest, and particularly so to the Lancashire visitor, was the ring frame made by the world-renowned firm, Platt Brothers & Co., Ltd., textile machinists, of Oldham. This firm may be looked upon as the doyen of manufacturers of textile machinery. It was established over a hundred years ago and has developed into a gigantic concern engaged in producing many kinds of textile machines both for spinning and weaving and for wool as well as cotton. Besides this the firm owns several coal mines.

The ring frame shown was an excellent example of the high class of workmanship turned out by the firm. At the exhibition it was spinning warp or twist yarns on wood bobbins and had 64 spindles, 2½in. gauge, 5in. lift, and 15/8in. rings. In some particular instances ring frames of extreme length are geared in the centre, as it is found that a steadier drive, so imperative for spinning fine yarns, is obtained.

A 15b.h.p. three-phase induction motor, made by Messrs. J. P. Hall, on whose stand the ring frame is being shown, is employed for driving. The motor drives the tin roller shaft of the frame through two "Hele-Shaw" clutches, the employment of which enables the frame to be started up gradually. The frame is fitted with a metal bobbin box and altogether is a very finished product. An interesting feature of its construction is the application of different forms of lappets. Lappets are employed to support the thread wire through the guide eye of which the thread passes from the nip of the delivery rollers to the traveller on the ring. It is necessary that these thread wires should be firmly held, but at the same time they should be easily adjusted if necessary. The old form of wooden lappet, examples of which were shown attached to the frame, possess many defects, and with the general advance made in the working of metals the metal lappet has come into existence. Two examples of metal lappet were shown on the frame—namely the type made by Messrs. Tyrler & Bowker and the type made by Messrs. Cook & Co. An inspection of these lappets and a comparison between them and the wooden lappet shown readily demonstrated the advantages possessed by the former type. Altogether the exhibit was a most interesting and noteworthy one.

Robertson Lamps.

THE exhibit of Robertson Electric Lamps, Ltd., was based on the lines of their popular exhibit at the Olympia Electrical Exhibition, but in addition to the stand, the firm, who have since acquired a large glass-works in England, showed a model of one of the glass cones at their Leamington-on-Tyne works.

The stand occupied one of the most prominent positions in the centre of the building, and formed one of the most attractive features of the exhibition. Several skilled operators from the Hammersmith Works were in attendance to demonstrate some of the processes of the manufacture of the well-known "Robertson" lamps. Owing to the very stringent regulations governing public exhibitions several of the most interesting processes of glow-lamp manufacture could not be shown. The operations shown

FIG. 1. EXHIBIT OF ROBERTSON ELECTRIC LAMPS, LTD.

FIG. 2. TESTING ROBERTSON LAMPS.

included blowing the glass bulbs; attaching the glass tube to bulb ready for exhausting; mounting the filament on to the platinum wires; sealing the filament into the glass bulb; and exhausting the air and gases from the lamp by aid of vacuum pumps.

In a show case on the stand were to be seen specimens illustrating the lamps in various stages of completion.

At all electrical exhibitions lamp-making "while you wait" attracts and holds the attention of the visitors, and the "Robertson" exhibit proved no exception to the rule. At times the press was so great round the three sides of the "stand" that the adjoining passages were quite blocked.

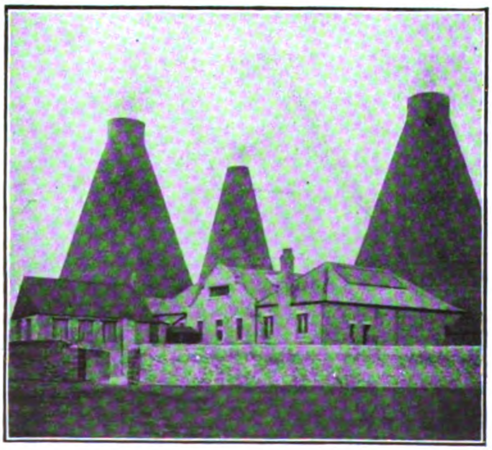
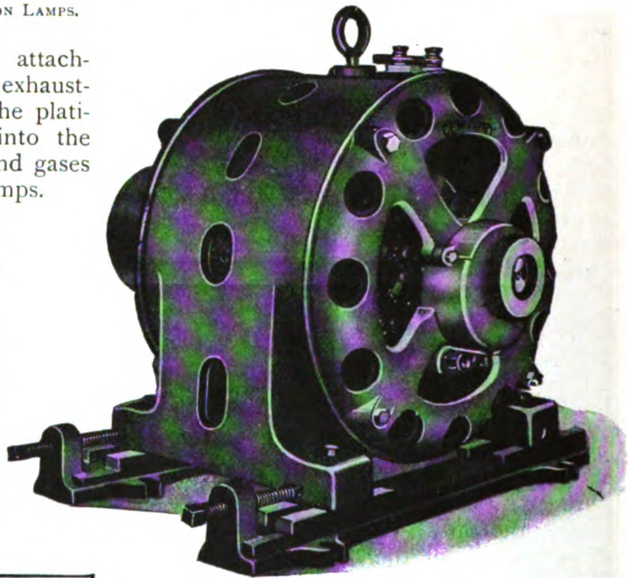


FIG. 3. GLASS WORKS OF THE ROBERTSON LAMP COMPANY.

Marples, Leach & Co., Ltd.

MESSRS. MARPLES, LEACH & CO., LTD., had a very varied display on this stand, covering nearly every branch of electrical manufacture.

A number of shunt and compound wound direct-current motors from 43h.p. to ¼h.p. were shown, and also a number of polyphase and single-phase machines. With regard to the latter a special type of single-phase motor capable of starting up against full load caused a good deal of interest. This motor was shown in operation and a very large starting torque was particularly noticed.

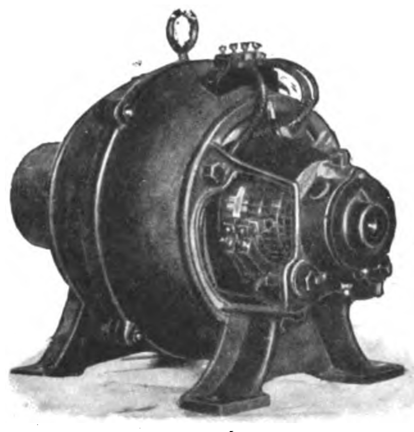


"ADNIL" SINGLE-PHASE MOTOR.

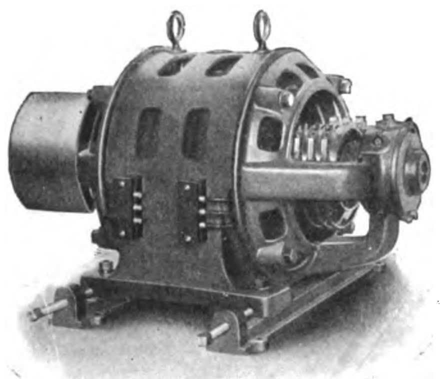
A 30h.p. three-phase motor with wound rotor and slip-rings, and provided with brush lifting and short-circuiting device, was also seen in operation, the rotor starter being of the liquid type. It should be mentioned that for the larger machines which were actually in operation a special form of water-tight enclosed switchbox was used, both double and three pole, provided with an ammeter; contained in the same box are a set of replaceable type fuses. A very valuable feature of these switchboxes lies in

the fact that it is impossible to open the door to get at the fuses while the switch is in the "on" position, and further, as long as this door is open it is impossible to close the switch, thus making the switchbox absolutely fool-proof.

In connection with the direct-current machines one of the most interesting features was a new type of auto-starter suitably called the "Direkton." As its name implies all that it is necessary to do is to throw the switch right in. This makes the main contact, and at the same time a spiral spring is compressed; this spring gradually releases itself, the speed at which it does so being controlled by a dashpot. In releasing itself the resistance is gradually cut out at a predetermined speed. This starter is provided



"Adnil" Type K.O. Motor.



"Adnil" Three-Phase Motor.

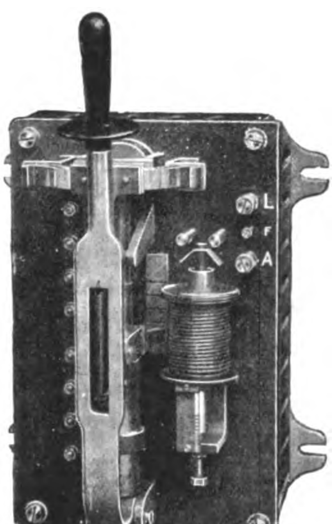
with a no-volt release, and also if necessary with overload release. The resistances are of very substantial construction, and it is to be noticed that these are so liberally dimensioned that a motor can be started up against full load very frequently without any ill effects. This starter is supplied with a cast-iron cover, so that it is as near a fool-proof piece of apparatus as can be devised.

A special type of series-wound totally enclosed and dust-proof crane motor, 25h.p. size, was also shown, the top half of the housing being removed so as to permit of inspection of the excellent workmanship and finish of the machine. One of the squirrel-cage three-phase motors was also dismantled so as to show the special type of rotor which is used in this make of machine. The windings of the rotor are stamped out of copper sheet, bent up and pressed into their position. This makes an absolutely jointless rotor and continuity right through the windings. There are no rivets or solder used, in fact no joint of any kind.

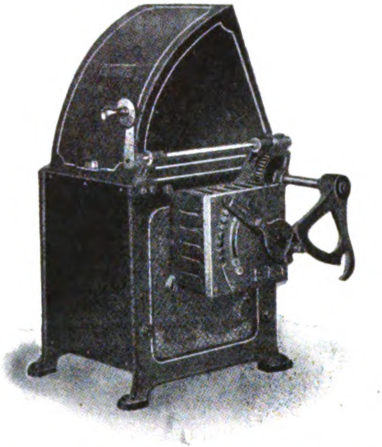
One of Marples' patent automatic organ regulators was also shown in operation. This is for use with organ-blowing outfits for direct current and combines the functions of both starter and regulator, only a single-pole switch being required.

A number of small-power motors for direct and alternating current, polishing lathes for all kinds of current, and a number of sensitive drilling machines with motors attached were also on view.

An interesting exhibit also was a geared



"Direkton" Motor Starter.

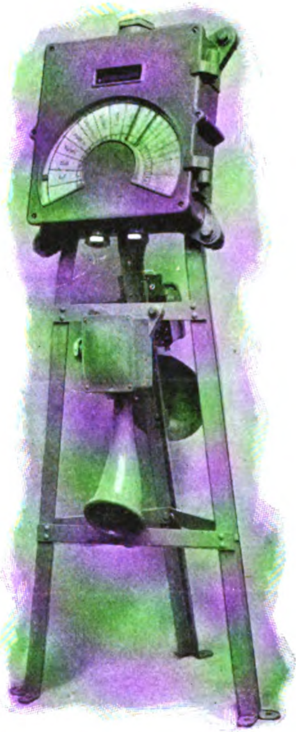


"Adnil" D.C. Liquid Starter with Interlocked Field Switch.

pump driven by a small three-phase motor. The pump is of extremely small proportions, being in fact a $\frac{3}{8}$in. size which could be seen steadily pumping over one gallon of oil per minute against a pressure of 275lb. per square inch. The special feature of the pump enabling it to work against such a heavy pressure could be seen in a similar pump, but of larger size, where the special hydraulic grooves were visible.

"Adnil" Electric Master Clock.

A large number of fans of all types were on show, from a 6in. desk fan up to ceiling fans. A new type which was exhibited was a specially silent fan. This type has a high-speed motor, consequently of very small size, driving a large-diameter fan at a slow speed by means of a friction reducing gear. These were shown both in wall and desk types. There was also shown a "Blizzard" fan, which is provided with a special type of blade, and for which it is claimed that it can move a larger quantity of air than any other fan of its size.



Receiver of "Adnil" Mine-Signalling System.

A great deal of interest, especially among mining engineers, was shown in the very varied exhibit of telephone material and signalling apparatus, including loud-speaking telephones for engine-room work, watertight telephones, trembler and single-stroke signalling bells, with other operating gear. Various types of desk telephones, intercom-

"Adnil" Water-tight Motor Switch Box.

municating telephones, and electric clocks were also shown.

An entirely new invention, the "Adnil" vibratory generator, was at work producing 75 volts alternating current from two ordinary dry cells. This instrument has been de-

signed for use when current for ring-bells is required and is likely to fulfil a long-felt want. For instance the little instrument is capable of ringing ten polarized 1000-ohm bells connected in parallel from two No. 2 dry cells.

A signalling system for underground haulages, shunting depots, or marine work, was also shown. This apparatus, while giving a new signal, automatically keeps a record of the last signal which has been transmitted. This apparatus is also constructed so that a record of every signal which has been made is kept.

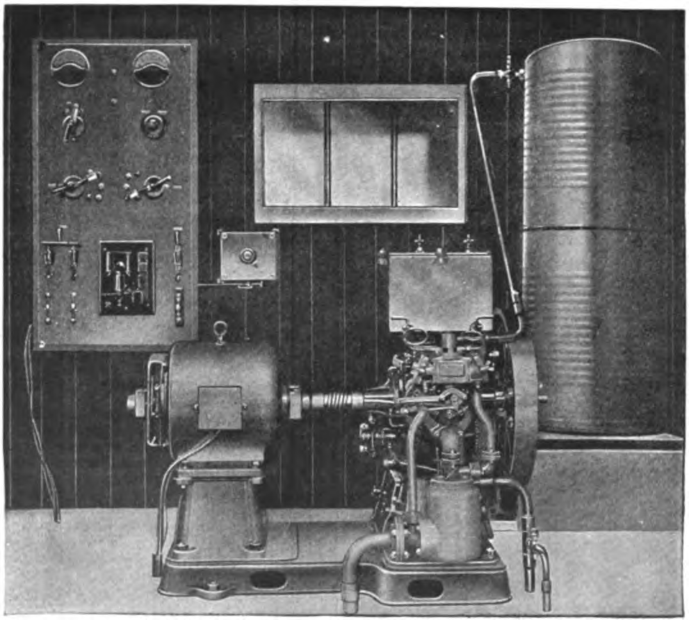
On the stand was a very fine display of yellow and white flame arc lamps, and also an arrangement of metallic-filament lamps, working on 200 volts and also on 100 volts.

A large number of switches, cut-outs, and lighting accessories were shown, as well as watertight fittings of all kinds. A very fine display was made of brass armoured and steel screwed conduit.

Among the side shows on this stand were a very compact and substantial star delta switch, three-phase and direct-current overload crcuit-breakers, a two-phase tramway-type controller, oil-immersed auto-transformer, meters, voltmeters, and ammeters of various types, and a show-board of cartridge fuses, watertight and brass hooters for works and motor-car purposes respectively. A motor-driven fire alarm bell could be heard not only at this stand but all over the exhibition.

Small Power Plants.

THE exhibit of the Heatley-Gresham Engineering Company, Ltd., who are specialists in the equipment of small private electric installations, consisted of a complete "Rational" electric lighting set capable of lighting, from a battery, 228 10c.p. metallic-filament lamps for ten hours. The set comprised a 6b.h.p. "Rational" patent oil engine and a 3½kw. 50-volt "Zone" dynamo direct-coupled by a spring coupling, and mounted on a cast-iron combination base plate. The switchboard was fitted with moving-coil instruments, quick-break switches, change-over switches to read current both during charge and discharge, an auto cut-in and cut-out of the best make, which is claimed to be a most valuable and important unit of the plant. The battery working in conjunction with this plant comprised twenty-seven cells of Pritchetts & Gold's manufacture. The complete set was shown at work lighting the stand.



A "RATIONAL" ELECTRIC POWER HOUSE.

Other exhibits included a 3b.h.p. "Rational" patent oil engine and a 1.2kw. 25-volt dynamo by the Electric and Ordnance Accessories Company, direct-coupled by a spring coupling, and mounted on a cast-iron combination base-plate (this set when complete with its battery and switchboard is the most popular for lighting medium-sized houses); a 2b.h.p. "Rational" patent oil engine; and a 1kw. 25-volt Siemens dynamo direct-coupled by a spring coupling, and mounted on a cast-iron base plate (the switchboard to be used was also exhibited, and the set is very compact

and suitable for moderate-sized houses, yachts, &c.); a 12b.h.p. "Rational" patent oil engine and a 7½kw. 100-volt dynamo by the Electric and Ordnance Accessories Company, direct-coupled by a spring coupling, and mounted on a cast-iron combination base plate (this set is suitable for large houses, moderate-sized hotels, &c.); a 3h.p. combined "Rational" engine and vacuum pump, suitable for working vacuum cleaners, milking machines, &c.

Metallic-filament lamps are recommended for use in connection with these plants, and the three sizes shown were of a voltage to give the most economical results with these lamps, viz., 50 volts, 25 volts, and 100 volts.

Obituary.

THE intelligence of the death of Professor W. E. Ayrton, F.R.S., which occurred on the eve of our closing for press, in the early morning of the 8th inst., will be deeply regretted throughout the world of electrical engineering and physical science. As Professor of Physics at the Central Technical College since the foundation of that renowned institution in 1884, Professor Ayrton was most intimately connected with the early training of a very large number of engineers, a great proportion of whom now occupy leading positions in every part of the world, and who will all receive the sad news with painful surprise, for the deceased Professor was only sixty-one years of age, and was one who always took the liveliest interest in the work and welfare of his pupils engaged in the world of business.

Educated at University College, London, Mr. Ayrton entered the Indian Government Telegraph service in 1867, and from 1873 to 1878 was Professor of Natural Philosophy and Telegraphy at the Imperial College of Engineering, Japan, where he was intimately associated with Professor J. Perry. The results of the electrical and physical researches of this collaboration are known to everyone connected with electrical matters.

Professor Ayrton was president of the mathematics and physics sections of the British Association in 1888, president of the Physical Society, 1891-92, and president of the Institution of Electrical Engineers, 1892.

New Catalogues.

Metal Filament Lamps. — ARMORDUCT MANUFACTURING COMPANY, LTD., LONDON, E.C., send us illustrated price list of "Gral" lamps of various types and Armorduct accessories for use in conjunction with these lamps. The "Gral" lamp possesses great improvements upon the early types of metallic-filament lamps, the capacity having been reduced by from 20 to 25 per cent., making the lamp more suitable for ordinary lighting conditions, whilst its appearance is enhanced by the reduction in size. The makers claim that the method of manufacture employed ensures a much stronger filament than it has been possible to secure hitherto, whilst by the method employed for supporting the filament breakages are very considerably reduced, the filament being given a natural spring support on which it is free to move.

Resistance Apparatus.—UNION ELECTRIC COMPANY, LTD., LONDON, S.E. List No. 6020, sections 1, 2, and 3, deals with resistance apparatus for direct and alternating current circuits. The range of shunt field regulators has been extended to very large watt capacities, and also to include the synchronous operation. both hand and automatic, of field regulators, of which a very full description is included. Of interest also are the main circuit regulators, and the ranges are practically unique. Laboratory and other special resistance apparatus are dealt with further on in the list, which concludes with dimension details of the apparatus priced in the foregoing pages.

Superheaters.—HEENAN & FROUDE, LTD., MANCHESTER. Catalogue No. 22 describes and illustrates the Foster patent superheater, of which Messrs. Heenan & Froude are the sole makers outside the U.S.A. In addition to other features which distinguish its construction from other types, the makers claim lower cost of maintenance. Illustrations are given of the Foster superheater installed in the principal land and marine boilers, including such types as the "Babcock & Wilcox," "Stirling," "Heenan," as well as in Lancashire and other types of boilers.

Dynamos, Motors, &c. — JOHNSON & PHILLIPS, LTD., CHARLTON, S.O., KENT. Leaflet B deals with continuous-current dynamos and gives prices for shunt and compound wound machines for open, protected, or totally enclosed types, both for 110, 220, and 440 volts. Leaflet C gives prices of alternating-current motors and starters, the motors listed being for two or three phase, and the prices cover for machines with wound rotors and also short-circuited rotors for pressures up to 500 volts. Both protected, ventilated enclosed, and totally enclosed type machines are dealt with. Leaflet G is devoted to switchboards and switchgear, leaflet L dealing with alternating and continuous current electric fans of the desk, porthole, box-blade, and ceiling types, with full particulars of the circuits for which they are suitable. These lists have been carefully coded for the convenience of clients residing abroad, and copies will be sent on application to anyone interested.

Ammeters, Voltmeters, &c.—JOHNSON & PHILLIPS, LTD. Leaflet I deals with various types of ammeters and voltmeters, including those of the permanent magnet moving coil type both in iron cases and in sector and edgewise patterns, and also in portable form. Hot wire ammeters and voltmeters are priced both in round iron cases and in the portable type. Spring-controlled dead-beat moving iron ammeters and voltmeters are listed both in iron cases and in sector pattern cases. Leaflet F deals with single and three phase transformers of air or oil cooled type. Prices are given for the air-cooled transformers in single-phase up to 50k.v.a., and in the three-phase up to 75k.v.a.; and for the oil-cooled transformers, single-phase, prices are given up to 150k.v.a., and in the three-phase type up to 225k.v.a.

Insulators, &c.—JOHNSON & PHILLIPS, LTD. Leaflet M deals with a number of styles and types of porcelain insulators, together with the necessary bolts and fittings required for erecting this type of material. Leaflet Y deals with Paterson's bitumen damp-proof sheeting. Both lists are coded: copies may be obtained on application by anyone interested.

Steam Turbines.—BRITISH THOMSON-HOUSTON COMPANY, LTD., RUGBY, send us two pamphlets, Nos. 211 and 212. Pamphlet No. 211 deals with Curtis steam turbines of the horizontal-shaft type, 1000kw. size. Pamphlet No. 212 describes and illustrates Curtis vertical steam turbines.

Accumulators.—PRITCHETTS & GOLD, LTD., LONDON, S.W., send a copy of their latest publication, which is, however, only some advance sheets of a larger and fuller catalogue which will be issued later. The advance pages give capacities, weights, and dimensions of this firm's standard "H" and "C" type cells in glass boxes.

"Tantalum" Lamps.—SIEMENS BROTHERS' DYNAMO WORKS, LTD., LONDON, E.C., send us a neat little pocket-size booklet containing illustrations and particulars of the various types of "Tantalum" lamps. A few reproductions of photographs of installations showing brilliant effects of lighting with "Tantalum" lamps are included. Copies of this booklet will be sent to any of our readers on application to the Incandescent Lamp Department, 6, Bath Street, City Road, London, E.C.

Messrs. Le Carbone send us a noteworthy souvenir of their success at the Franco-British Exhibition. This takes the form of a beautiful replica of the medallion in graphite, and apart from its extremely artistic appearance it is of exceptional interest as showing the high degree of perfection which this firm has attained in the working of carbon and graphite to meet commercial requirements.

Trade Notices, &c.

The British Westinghouse Electric and Manufacturing Company, Ltd., announce that Cooper Hewitt mercury vapour lamps, hitherto manufactured in France and Germany, are now being manufactured in England for sale direct to users and the trade. Enquiries for these lamps should be addressed, as heretofore, to the British Westinghouse Company at Trafford Park, Manchester, or any of their branch offices.

Awards.—We understand that the juries of the Franco-British Exhibition have awarded Messrs. Wm. Geipel & Co. the Diplôme d'Honneur for Liconite cables, also that Mr. Geipel has been awarded a gold medal for his world-renowned steam trap.

Combination Metallic Packing Company, Ltd., advise that they have been awarded a gold medal and diploma at a Special Exhibition in Russia.

Messrs. Pritchetts & Gold, Ltd., advise that they have received an order for a fresh battery of 210 cells from the Epsom Urban District Council for their electric light works.

BOOKS RECEIVED.

Scientific Ideas of To-day, A POPULAR ACCOUNT OF THE NATURE OF MATTER, ELECTRICITY, LIGHT, HEAT, &c., IN NON-TECHNICAL LANGUAGE. BY CHARLES R. GIBSON. WITH FORTY-TWO ILLUSTRATIONS AND DIAGRAMS. (LONDON: SEELEY & CO., LTD., 38, GREAT RUSSELL STREET. PRICE 5S. NET.)

Logarithms for Beginners. BY CHARLES N. PICKWORTH. SECOND EDITION. (LONDON: WHITTAKER & CO., 2, WHITE HART STREET, PATERNOSTER SQUARE E.C. PRICE 1S.)

The Slide Rule, A PRACTICAL MANUAL. BY CHARLES N. PICKWORTH. ELEVENTH EDITION. (LONDON: WHITTAKER & CO., 2, WHITE HART STREET, PATERNOSTER SQUARE, E.C. PRICE 2S.)

Outlines of Electrical Engineering. BY HAROLD H. SIMMONS, A.M.I.E.E., ILLUSTRATED. (LONDON: CASSELL & CO., LTD., LA BELLE SAUVAGE, E.C. PRICE 21S.)

"Mechanical World" Electrical Pocket Book, FOR 1909. CONTAINING A COLLECTION OF ELECTRICAL ENGINEERING NOTES, RULES, TABLES AND DATA. (MANCHESTER: EMMOTT & CO., LTD., 65, KING STREET. PRICE 6D. NET.)

Handbuch der Elektrotechnik, VOL. V. DYNAMOBAU. BY KARL PICHELMAYER. WITH 432 ILLUSTRATIONS, INCLUDING 24 DRAWINGS. (LEIPZIG: S. HIRZEL. PRICE 36 MARKS.)

Handbuch der Elektrotechnik, VOL. XI., PART 2. WÄRMETECHNIK UND SIGNALWESEN. BY V. ENGELHARDT, DR. ING. K. HOHAGE, H. FREYTAG, H. SCHWERIN, R. VOGEL. WITH 541 ILLUSTRATIONS AND 26 DRAWINGS. LEIPZIG: S. HIRZEL, PRICE 27 MARKS.)

The

Electrical Magazine.

Vol. X. No. 6. LONDON. December 15th, 1908.

The World's Electric Progress.

Modern Electric Lamps.

So rapid have been the advances made of late in the production of improved and altogether new types of electric lamps, that a concise statement of facts dealing with the principal forms will be found of considerable interest and advantage.

The carbon-filament incandescent lamp which has held sway for so many years as the standard electric lighting source, although undoubtedly destined to give way to more recent forms, has reached its high-water mark with an electrical consumption of from 3 to 3½ watts per candle-power, and a life of from 800 to 1000 hours. The carbon-filament lamp has latterly been improved by metallising the filament. The compound filament thus produced exhibits to some extent metallic properties of advantage, particularly that which gives a rising temperature co-efficient of resistance. The cost of these lamps is very little more than that of the ordinary carbon-filament lamp; their current consumption is, however, about 33 per cent. less.

It was after the appearance of the metallised-filament lamp that the Nernst lamp appeared on the market, giving a current consumption of 1.5 to 1.7 watts per candle-power, and a life averaging about 400 hours. The merits of the Nernst lamp in the way of current economy and suitability for direct use on the higher-pressure circuits up to 220 volts, were offset by its first cost and its liability to failure owing to its mechanical complexities. There can be no doubt, however, that the perfecting of metallic-filament lamps has practically put the Nernst lamp out of the running. Of metallic-filament lamps the use of the metal osmium was introduced by Welsbach. These lamps consume about 1½ watts per candle-power, and have a life of about 1000 hours. The leading disadvantages of the osmium filament were its high cost; great ductility when heated, preventing the lamps being burned in any but one set position; extremely high conductivity, which prevented the manufacture of lamps for any higher pressure than 30 to 40 volts. The osmium lamp has been superseded by more recent metallic-filament lamps of the tantalum and tungsten or wolfram types. Of these, the tantalum lamp, introduced by Messrs. Siemens, has a life of about 800 hours and a current consumption of about 1.7 watts per candle-power, and is made for single use on pressures up to 120 volts.

As the latest step in the development of metallic-filament lamps we have those of tungsten, which are now made for single use on circuits of voltages up to 200 volts in units of from 25 to 100 candle-power. These lamps have now been improved up to the point at which the filament can be depended upon to withstand the lamp burning in any position. Their useful life is from 1000 hours upwards; one of the most important

properties is that throughout the life of these lamps they show no appreciable diminution either in candle-power or efficiency; and whereas the tantalum lamp, for instance, is most suitable for use with direct-current circuits, the tungsten lamps are equally serviceable on both direct and alternating current circuits.

There are already several firms engaged in producing lamps of this type, and the prices are rapidly coming down to such reasonable limits as to warrant their universal adoption in place of the carbon-filament types. In this connection we should refer to the notice displayed by the General Electric Company in our advertising pages. Within the short space of eighteen months millions of these lamps have been put on the market and various independent tests have been published showing a life varying from 1500 to 6000 hours, with a loss of candle power not exceeding 5 per cent. to 10 per cent. It is only natural that these conditions have enabled the manufacturers to make economies at the works, and they now announce considerable reductions. Already the voice of station engineers who have been afraid of a reduced income is becoming fainter. Many of them have recently testified to the fact that, though individual accounts have diminished, the total revenue of the station has not suffered but, in many cases, increased. If the electrical trade will take full advantage of the new conditions, there ought to be plenty of work ahead for the contractor for some considerable time.

Whilst the phenomenal progress made in the design of incandescent-electric lamps is undoubtedly the most prominent and important feature of present-day electrical development, destined beyond doubt to make the use of electricity in very truth universal, there are also further great improvements in the larger lighting sources to be recorded and borne in mind by industrial consumers. The use of flame arc lamps has already become general and there are very many types and designs to select from. Their prices are reasonable and they give an average current consumption of from .2 to .25 watts per candle-power, with a length of burning, for a single pair of carbons, of from ten to twelve hours. The current consumption given refers to the more commonly used type of flame arc, that is the one which emits the golden-yellow light usually desired for general illumination; where a pure white light is desired, or at all events can be adopted, the use of special electrodes permits of an economy in the neighbourhood of from .15 to .2 watts per candle-power, these figures being those which accompany the use of, for instance, Siemens' "Alba" carbons.

Whilst the mercury-vapour lamp can hardly be said to appeal to the general consumer, owing to the strange and usually considered repellant colour of its light, still it undoubtedly has a commercial field before it. For example, it is already in some considerable use in warehouses, drawing offices, and in workshops where the finer grades of work are engaged in. It also has the noteworthy advantage of a high actinic value, and as such will doubtless be taken up more largely for photographic purposes. The better diffusion which the mercury-vapour lamp affords, as compared with the electric arc, at once places it in an advantageous position for photo-mechanical processes. The efficiency of the mercury-vapour lamp ranks about the same as that of an ordinary arc lamp, the lamps themselves having a life of about one thousand hours. The latest form of mercury-vapour lamp is one in which quartz is used for the enclosing tube. This permits the use of higher temperatures than does glass, consequently the length of the arc can be reduced, the lamp occupying a much smaller space and the light efficiency increased to about twice that of the older form. These lamps can be used direct on 220-volt circuits, but are suitable only for use with direct currents. The average life of the quartz lamp is about one thousand hours, and this, when considered with its great economy, at once stamps it as a lamp destined for a very considerable use in industrial service

where the colour of the light is of secondary consideration, and for special services such as those outlined.

Electrobuses. THE business and affairs of the London Electrobus Company have been in considerable prominence of late. Financially the Company has found it necessary to invite further capital, but it is not within our province to discuss the company from the shareholders' point of view. It is to be recorded, however, that so far as actual operation is concerned the buses have so far proved successful. At the same time it is not yet possible to give definite figures with reference to the upkeep of the power equipments. The makers of the batteries, Messrs. Pritchetts & Gold and the Tudor Accumulator Company, are still working more or less in the experimental stage, and the prices quoted by them for the maintenance of the batteries are merely tentative, and only practice during the next few months will show whether these prices can be adhered to or not. It is very certain that as compared with the petrol bus the accumulator bus has very much to recommend it, as those acquainted with the London traffic will agree.

The latest improvement suggested is that the Electrobuses should have covered-in tops, and two of the buses have been fitted with covers to demonstrate the feasibility of the proposal and to gain the consent of the Scotland Yard authorities to the innovation. Two buses with covered tops were given a trial run along a circuitous route in the City. Passing beneath the railway arch at Ludgate Circus there was a minimum clearance of 2ft. between the top of the outside cover and the bridge. The buses carried a full complement of passengers and fully demonstrated their hill-climbing capabilities and general stability. The top covers are arranged for side windows of glass, to be replaced by curtains for the warmer months, and the top seats are placed transversely along the centre of the bus, leaving a 17in. gangway at either side. There are 6 of these seats, each accommodating 3 passengers. The inside seating accommodation of the bus is 18, so that 36 passengers form the full complement.

Top covers for buses have hitherto been objected to by the police authorities, mainly on the ground of the top-heavy effect. The Electrobus has the advantage that it carries the accumulators, which weigh about 30cwt., below the level of the axles, consequently the centre of gravity is extremely low and the whole vehicle certainly quite stable.

The electrical equipment of the two covered-in buses differs somewhat from that of the others in that the driving power has been subdivided to provide a motor for each wheel. The motors are built into the hubs of the wheels, each being an 8h.p., 8 pole series machine of the Lohner-Porsche type driving direct on to the axles. The batteries consist of 47 cells, having a capacity of 400 ampere-hours, this being sufficient to give a run of 40 miles with one charge. The addition of the top cover adds about 300lb. to the weight of the bus, but even then the average current reading during the trial runs was only 85amp., as against an average of 90amp. for the open-top buses running regularly. This is doubtless due to the greater efficiency of subdividing the motor driving power. The control is of the series-parallel type, having six forward and two reverse speeds and one braking position.

At the luncheon which followed the covered bus demonstration Mr. T. J. Garlick occupied the chair and gave some interesting particulars of the operation of Electrobuses. In the past fifteen months the Electrobuses, of which there were an average of seventeen running, had carried some 3,000,000 people. Regarding the contention that the top cover tended to make the bus top-heavy and liable to capsize, he said it would require an 80-miles-an-hour gale to cause any lifting of the bus wheels. The present takings of the company averaged 14d. per bus mile, and it was anticipated that

with the use of the covered tops this would be considerably improved. Whereas now with open tops each bus earned annually some £500, it was estimated as not unreasonable that the earnings with covers would be in the neighbourhood of something over £600 per annum.

Electric Ear Bath.

THE Electro-Chemical Ear Bath, as it is termed, is an invention by Mr. Martin Kroeger, its use being to facilitate the treatment of ear complaints by what is known as cataphoresis. This is the name given to the property which electricity has of diffusing fluids and substances through other fluids and substances, and by which it is possible to pass various medicaments through the unbroken skin, and thus rapidly to impregnate the tissues with certain drugs. In aural cases, cataphoresis can be of very great value, because it enables remedies to be applied to parts of the ear which, otherwise, it is most difficult to reach. For this reason the invention is one likely to be of great value to those afflicted by deafness or otherwise interested in the treatment and cure of diseases of the ear.

The bath proper consists of a round glass vessel to contain the solution it is intended to apply and fitted with a non-conducting nozzle for insertion in the ear. In the centre of the bath there is fixed a carbon electrode connected by wire to one pole of the electric battery or some other suitable source of supply. The opposite pole of the battery is held by the patient in his hand. In use the bath is filled with a solution containing the prescribed therapeutic substances, then, the nozzle being inserted in the ear, an electric current is passed through the electrode into the fluid, and, the head being slightly tilted, both fluid and current flow into the ear: the electricity thus passes through the body of the patient, the circuit being completed by the pole of the battery which he is holding in his hand.

In its passage, the current carries with it the medicament contained in the bath, and in this manner, as standard authorities have testified, it is possible to obtain most valuable therapeutic results in aural cases. Thus, Scheppegrell quotes a case of eczema of the auricular canal which resisted all treatment for over a year, but was ultimately cured within three weeks by means of a 2 per cent. solution of guaiacol in pine oil, cataphorically applied. Cagney found iodide and iodide of potassium solutions of great benefit in cases of labyrinthine deafness, when applied by means of cataphoresis. Scheppegrell held the opinion that cataphoresis offers considerable possibilities in treating certain chronic conditions of the ear, and made extensive use of the method in his own practice.

The manufacturers of the bath advise their willingness to place it at the disposal of otologists who may care to try it in their practice. It will undoubtedly be found that the apparatus is of much service, especially as affording a useful and rapid method of applying cocaine anæsthesia to the external auricular canal. Masini obtained excellent results from the application of cataphoresis for the anæsthesia of the membrana tympani; solutions of 5, 8 and 10 per cent., when the current was continued for twenty-five, fifteen, and ten minutes, allowed him to perforate the membrana tympani without pain; solutions of from 5 to 10 per cent., with very weak currents, applied for five minutes, were sufficient to arrest otalgia.

Japanese Electric-power Developments.

IT is reported that preparations are now well in hand for the construction of the largest hydro-electric plant so far projected in Japan. The company are to put down three generating stations, about 100 miles west of Tokio, from which power will be transmitted in bulk. The first power station to be completed will be of 60,000h.p. capacity, the total cost being estimated at £1,750,000.

The water head available at this station is 600ft., the hydraulic work involving the construction of a dam 300ft. high and 700ft. long, to conserve the water of the Oi River. Six three-phase, 25-period, 6600-volt generators direct-coupled to 13,500h.p. vertical water-wheels will be installed, together with two 500h.p. direct-connected exciters and the necessary transformers for stepping up the supply to 66,000 volts. The length of the transmission line will be about 105 miles. Steel towers 50ft. high, with 450ft. span, will be used. The entire line will be in duplicate, so as to ensure continuous service. At the substation end of the line the voltage will be stepped down to 6600 volts, and current distributed in Tokio, Yokohama, and adjacent cities and towns. Contracts have already been made for the supply of about 20,000kw.

Wireless Telegraphy with Balloons.

A SERIES of wireless telegraphy tests with balloons was recently described in the *Elektrotechnische Zeitschrift.* The balloon Condor ascended in the neighbourhood of Brussels, and communications were made between it and a station erected in the tower of the Brussels Palace of Justice. Morse signals sent from the Eiffel Tower, in Paris, were also clearly received by the balloon. That the German Airship Battalion has made extensive experiments with wireless telegraphy has been already recorded. The apparatus used were furnished by the Telefunken Gesellschaft. Several years ago Professor Hergesell, of Strassburg, made some tele-mechanical experiments with unmanned registering balloons. Attached to the same were small receiving stations, which, upon the arrival of the electric waves, actuated a valve and caused the balloons to fall. Each balloon was attuned to a certain wave-length. Thus it was possible for the vessel, from which the balloons were sent up, to bring down any one of them at will, while the others remained in the air. The experiment was successful up to a distance of ten nautical miles, and wireless communication between flying balloons and land stations was at that time already considered possible. But at the airship trials this year it was feared that, if wireless apparatus were taken on board, sparks might be generated, which would cause serious consequences by exploding the gas. However, it would seem to have now become possible to remove this danger and to guarantee a safe wireless communication between balloons.

New Fire Alarms.

WITH the view of improving the London metropolitan fire-alarm system, experiments have been conducted with a new type of apparatus, which has the following advantages over that now in use:

(*a*) When the fire-alarm is pulled all the electric bells throughout the fire station are actuated, instead of only the bell in the watch-room, as at present.

(*b*) When there is a fault on a fire-alarm circuit only one bell in the watch-room of the station rings, thus obviating the brigade unnecessarily turning out; and any small defect on a circuit is immediately indicated, which prevents the whole fire-alarm system in connection with a station being put out of working order, as sometimes occurs with the present apparatus.

(*c*) The person calling the brigade by means of the fire-alarm can be rung up from the fire-station, and telephonic communication can be kept up between the fire-alarm and the fire-station, a receiver being kept in the fire-alarm post for the purpose.

An experimental installation of this character has proved satisfactory, and in view of the great advantages of the new apparatus the chief officer of the brigade recommended that it should be adopted for the fire-alarms connected with all stations, and for all new fire-alarm posts to be fixed in future. He pointed out that by its adoption the existing fire-alarm system, which

is considerably out of date, would be modernised and made as satisfactory as is at present possible; and that in the alternative he would feel compelled to recommend the installation of an entirely new and modern system, which would be a very costly matter.

Having seen the proposed new pattern of apparatus, and very carefully considered the matter, the Fire Brigade Committee of the L.C.C. entirely concurred in the chief officer's recommendation, and proposed that the new apparatus should be adopted without delay. There are about 1300 fire alarms in London, and from estimates supplied by the Post Office, who provide and maintain the whole of the apparatus for a yearly charge, it appears that the cost of adapting these to the new system would be about £3500. In addition the annual charge for fire-alarms would ultimately be increased by about £425, less £120 saved by the abolition of portable telephones.

Windmill-electric Power.

We have several times found occasion to refer to the advantages which a windmill-electric plant offers to the small power user in isolated districts. Such plants particularly appeal to the farmer and occupiers of small country houses. The primary source of power costs nothing; the air-motor and electric plant is of low first cost, easily installed, requires a minimum of attendance, and its upkeep is almost insignificant. Whereas the output of a windmill plant is small and is only suitable for the lighter power services such as the driving of churns, separators and the smaller agricultural or dairy machines, the use of electric plant renders the operation of the system almost entirely automatic. Many of these plants are to-day in successful operation of capacities ranging from 3h.p. to 30h.p., and some firms, notably the Oerlikon Company, have made a speciality of designing complete equipments which shall be as automatic in control as possible. The vanes of the sweeps or wheels are so arranged that they can accommodate themselves to the pressure and direction of the wind, and the other features of the windmill are as generally used in air-motors for direct pumping work, &c.

The ordinary electric equipment consists of a direct-current dynamo, a storage battery, and two automatic regulators. By means of the latter the storage battery is maintained at its normal voltage and capacity. The excitation of the generator is also controlled automatically. During operation the storage battery is fed by the generator, except when there is a demand for power, and the battery then comes into use to assist the generator.

When the storage battery becomes fully charged it is automatically cut-out of the circuit and the generator supplies the load when the prevailing wind is sufficient. The battery is automatically thrown into connection with the line again when the power demand exceeds the then capacity of the dynamo. With no-load on the circuit and with the fully charged battery cut out the generator is free to run idle.

Electric Brush for Cleaning Ships' Hulls.

Many devices have been invented to clean a ship's fouled bottom without the necessity for docking, and perhaps the most effective of these was the old-fashioned hogging brush with which the submerged parts of the hull were scrubbed, but difficulty was always experienced in applying sufficient force to the brushes. A new form of electric brush has recently been introduced and is said to have given good results. It consists of a set of electromagnets mounted on the brush battens which serve to hold the bristles firmly against the iron or steel hull of the ship while the "mat" or set of brushes is being dragged backwards and forwards over the surface. The principal brushes are set at an angle on the working battens to make the apparatus self-clearing, while other brushes set square precede the magnet poles, affording them a clean surface on the hull to which to adhere.

The pole pieces are rocker-shaped, being arranged to cant the brushes and so secure a flicking action against the accumulated matter. The current for exciting the adhesion magnets may be supplied either from the ship itself or from a special tender lying alongside, and the entire mat is dragged back and forth across the bottom of the hull by a steam or electric-power winch. A tractive effort of about 3000lb. is required to drag the mat against the resistance imposed by the average accumulation of marine material and friction at the pole pieces. The gear is very simple, and several men from the ship's crew can clean a 4000-ton ship in eight hours at an expense of about £40, including cost of labour, magnet current and tractive power. An 18,000-ton battleship can be cleaned in twelve hours. It is said that the apparatus has proved entirely satisfactory in operation and vessels scrubbed by this method are found to be perfectly clean and free from marine growths when examined in dry dock.

Silico-vanadium Steel.

THE new silico-vanadium steel which has lately been used in the construction of transformers is now fully recognized as of great importance in decreasing transformer core losses, and the results obtained show such improvements in efficiencies as are of material value to central stations. While the use of this new alloy with its improved magnetic qualities has neccessitated more or less re-designing standard transformers, their general proportions remain practically as before. A writer in an American contemporary describes the physical properties of the new alloy, from which it would appear that it possesses other advantages than magnetic. Silico-vanadium steel is strongly crystalline in structure, in appearance much like a sheet of zinc or tin, although the colour of different samples varies on account of the different thicknesses of scale arising from the annealing process. When held so that the light is reflected from its surface this crystalline structure is most pronounced. Occasionally, samples will be found which are coated with a dark blue scale covering the surface of the metal, but when this is removed the characteristic crystalline structure is plainly discernible.

The susceptibility of silico-vanadium steel to oxidation during the annealing process is a very valuable commercial feature, for the reason that the exceedingly thin scale of film of oxide which forms on the surface is an insulator to the extent of rendering unnecessary the usual practice of painting or varnishing the transformer laminations. Insulating the laminations by paint or japan is not only expensive, but undesirable, for the reason that the japan or paint occupies some space, so that as much steel cannot be placed in a given section as would otherwise be employed.

A strip of silico-vanadium steel when bent assumes a semicircular curve and is highly elastic, whereas ordinary alloy or silicon steel similarly bent tends to fold in the middle. A further peculiar characteristic of silico-vanadium steel is the manner in which it breaks and the appearance of the fracture. While there is a slight variation in the hardness of this steel, some pieces breaking instantly like glass upon the first attempt at bending, other samples may be bent very sharply several times before snapping. The fracture is irregular and the crystals may be easily seen without the aid of a magnifying glass.

Anyone who is interested can thus readily compare the new steel with the various other alloy steels at present on the market by an examination of their physical appearance and also by the simple bending test mentioned above.

Electrical Manufacture in Australia.

IT would seem, according to the engineering correspondent of *The Financier*, that the Australian Government has just taken an important

step in the direction of the encouragement of electrical manufacturing in the Colony. Instructions have been given by the Postmaster General that Australian firms be invited to tender for 10,000 wall telephones, together with the associated electrical parts. It is further stated that the order may be extended to cover the supply of 30,000 telephones spread over a term of years, if by that means it is possible to establish this new branch of industry in the country. It is not necessary that the instruments should be precise reproductions of European models, and scope is given for fresh patterns, which will be favourably considered. It is also hoped that it may be possible to employ Australian timber for the wooden portions of the apparatus. It seems that a former invitation to tender for 5000 telephones, accessories, and parts of Australian manufacture failed to receive any response as regards the parts, while only two tenders were received for the instruments. In both cases the prices quoted were 150 per cent. higher than for the imported apparatus.

Electric Welding of Chains.

THE following note on the electric welding of chains occurred in a paper recently read before the Engineers' Society of Western Pennsylvania: Electric welding of chain was first tried about a quarter of a century ago, the method adopted consisting of taking two half links and joining them. Links as large as 3in. in diameter of stock have been made by this process, but it seems it had to be abandoned for large chain.

Recently electrically-welded chain up to ½in. or ⅝in. has been made commercially by automatically cutting the blanks from a bar so as to form a socket in one end and a corresponding taper on the other end of the link blank; this is then bent and joined on one side and these joints welded. This method obviates the usual amount of upset required for a good weld in such cases, and the laps, or area of contact, are much larger than in the squarely cut ends. The result is that a good sound weld, of neat appearance, is made.

THE TESTING OF INDUCTION MOTORS, WITH DETAILS OF TEST ON A 300H.P. THREE-PHASE MACHINE.

J. W. ROGERS.

BEFORE dealing with the subject of testing induction motors, which forms the main theme of this article, it may be well to mention a few elementary facts dealing with the calculations relating to the same and with the working of these machines. The primary current taken by a three-phase motor depends upon its output, terminal voltage, power-factor and efficiency, that is to say, the amperes per phase =

$$\frac{\text{H.p.} \times 746}{\text{Volts} \times \text{Real Eff.} \times \text{Cos}\ \phi \times \sqrt{3}},$$

the total current being given by amperes per phase $\times \sqrt{3}$. The primary current is made up of two components, viz., an energy and an inductive component. The energy component represents that portion of the current which is in phase with the voltage impressed on the primary winding, the inductive component representing the wattless part of the current which lags 90deg. behind the impressed voltage. The inductive component depends upon the magnetising current taken by a motor, and also upon its magnetic leakage, and as it gives rise to a lagging current it affects the regulation of the supply circuit. The value of $\sqrt{\text{energy component}^2 + \text{inductive component}^2}$ gives the apparent input to the motor, and the ratio of the energy component to this latter quantity represents the power-factor of the motor, and as a large inductive component will give a low power-factor, a motor must take a small magnetising current if its power-factor is to be high; the power-factor of a motor also depends upon its air-gap as this affects the magnetic leakage. The value of the energy and inductive components may be easily calculated when the power-factor and apparent input are known. As already stated, the apparent input = $\sqrt{\text{energy component}^2 + \text{inductive component}^2}$ then the inductive component =

$$\sqrt{\text{apparent input}^2 - \text{energy component}^2}.$$

Taking the case of a motor having a power-factor of 80 per cent., and substituting this in the above formula we get—
Inductive component = $\sqrt{100^2 - 80^2} = 60\%$, that is to say, the wattless component is 60 per cent. of the total input current, and this example clearly shows the necessity of having the power-factor of an induction motor as high as possible. The total power input to a motor includes the energy given up as brake h.p. on the motor shaft, also the losses taking place in the iron and copper circuits and those due to friction and windage. The apparent power given to a motor = primary amperes (total) × terminal volts, its true power being measured in watts by the two-wattmeter method; then the ratio $\frac{\text{true power}}{\text{apparent power}}$ represents the power-factor of the motor at that particular load. The shop tests carried out on induction motors may be classified under two distinct heads, viz., experimental and commercial. The tests generally made under the heading of experimental tests are those of—(1) resistance; (2) running, open-circuit, and locked saturation curves; (3) power and slip

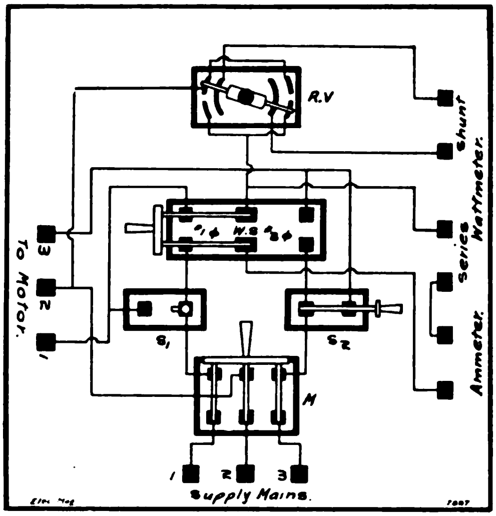


FIG. 1.

curves. These tests may be considered separately as follows :—

Resistance Test.

The resistances are measured between terminals, the mean value of the primary resistance being given by $R = r_1 + r_2 + r_3 \div 3$, where r = resistance between terminals. It is the custom with some manufacturers to allow for the increase in resistance due to heating by adding on about 10 per cent. to the resistance as measured at the temperature of the surrounding air, and it will be found that this has been done in the example to be considered later on.

Saturation Curves.

These saturation curves are made chiefly to serve as a check on the design of the magnetic circuit. The running saturation curves are obtained by running the motor light at various voltages, commencing with a voltage about 25 per cent. above its normal value, and taking readings of amperes per phase, terminal volts, and true watts. It may be mentioned that in all shop testing work it is the custom to measure the current with a Siemens dynamometer, which, although not direct reading, is more suitable for testing work on either direct or alternating current circuits. The current is measured in each phase, and its value as calculated from the instrument reading is given by $C = \sqrt{\text{divisions}} \times K$ where K is a constant determined by the calibration of the instrument.

Now the total current in a three-phase machine, *i.e.*, the current which when multiplied by the terminal volts gives the apparent watts input, is given by amperes per phase $\times \sqrt{3}$, then the total current as found from the dynamometer readings will be given by

$$C = \frac{K\,(\sqrt{d_1} + \sqrt{d_2} + \sqrt{d_3})}{3} \times \sqrt{3}$$

$$= \frac{K\,(\sqrt{d_1} + \sqrt{d_2} + \sqrt{d_3})}{\sqrt{3}}$$

In modern testing-shops wattmeter measurements are made by connecting the machines to test tables, on which are permanently fixed and arranged, in the most convenient manner, all the necessary instruments and switches required for this purpose. In Fig. 1 is shown the diagram of connections of such a table, arranged by the writer, and found to serve its purpose admirably. The advantages of such an arrangement are:—(1) Saving in labour required to wire up a test; (2) instruments are only in circuit during the time measurements are being made, which renders them free from (*a*) errors due to heating through being left too long in circuit, and (*b*) injury caused by shocks due to adjustments of load. Referring to the diagram, Fig. 1, WS is a two-way wattmeter switch; $S_1 . S_2$ short-circuiting switches; and M the main switch. The reversing switch, RV, is for the purpose of reversing the direction of the current through the voltage coil of the wattmeter when its readings are reversed due to a low power-factor. The watts are measured in either phase by first closing the switch WS, and then opening the short-circuiting switch attached to that phase.

During the saturation test the generator speed must be held constant to give the frequency required by the motor under test, and, from the results of the test, curves are plotted having total amperes and watts

as ordinates and terminal volts as abscissæ. The amperes curve may be compared to the saturation curve of a direct-current machine, and from it the magnetizing or no-load current taken by the motor at different voltages may be obtained. The watts curve represents the iron loss and friction at different voltages.

The open-circuit saturation test, which is only carried out on motors having wound rotors, is made chiefly as a check on the E.M.F.'s induced in the secondary winding when a given voltage is applied to the primary. It is carried out in a similar manner to the running saturation test, the readings taken being those of terminal volts, amperes per phase, watts, and volts across the slip-rings. From the results of this test curves are plotted having terminal volts as abscissæ, and secondary volts, watts, and amperes as ordinates.

The information to be derived from the curves of locked saturation enables the inductive component of the volts and also the effect of magnetic leakage to be calculated; a knowledge of the starting torque of the motor at different voltages is also obtained from this test. The test is made by fixing a brake arm to the motor shaft and connecting the motor to the circuit in a similar manner to that required for the running saturation test, the torque being measured by means of a scales. The motor is supplied with a low voltage, which is gradually increased to its normal value (if the output available will permit), the readings taken being those of terminal volts, amperes per phase, watts, and scales. The results of this test may be shown in the form of curves having kilowatts, total amperes, and lbs. torque as ordinates, and terminal volts as abscissæ. When the output of a motor is too large to allow of its torque being measured directly, it is the custom, in the case of machines having wound rotors, to measure the secondary amperes, an ammeter being connected in each phase of the secondary for this purpose. When the secondary current is measured, the resistance in the secondary circuit should be varied at the same time as the primary voltage. In cases where it is possible to measure the torque, its value is calculated from (scales reading – weight of brake-arm) × length of arm in feet.

Another test generally made at the conclusion of the locked saturation test is that known as the pulling-out or maximum-torque test. The voltage at which it is advisable to take the pulling-out torque of a motor depends upon its output. The resistance of the secondary circuit also has an important bearing on this point, owing to the fact that the pulling-out torque is very much greater than the starting torque when the resistance of the secondary is low. It will, therefore, be seen that the current taken by a large motor to give its pulling-out torque at normal voltage is liable to reach an enormous value. For these reasons it is advisable to take the pulling-out torque at a voltage considerably below the normal voltage of a motor, especially in the case of machines of large output.

This test is made by adjusting the voltage to its required value, which must be held constant. The brake is then tightened and balance adjusted on the scales from time to time, until the motor slows down rapidly without increasing the torque. The actual pulling-out point is reached when the motor begins to slow down, and at this instant a reading of the terminal volts and scales is taken.

Power and Slip Curves.

These consist of a series of curves representing the complete performance of a motor. They may be obtained either (1) directly from a brake test, in the case of small machines, or (2) by calculation from the losses.

The connections for the brake test are the same as for the locked saturation, but, as it will be running, the brake pulley must not be locked on the motor shaft, but act simply as a brake, being cooled by a stream of water. The motor is run for different values

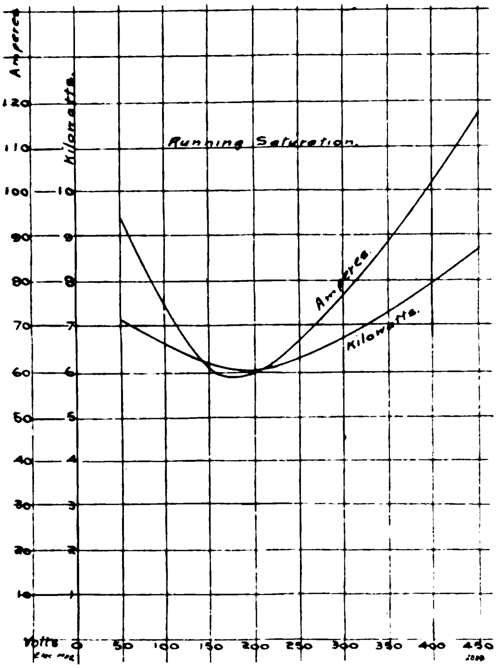


Fig. 2.

of torque representing different loads, its full load torque being calculated from the output and speed at that point. A complete set of readings covering about 25 per cent. overload is taken at each point, consisting of terminal volts, amperes per phase, watts, lbs. torque, motor and generator speeds; during this test the terminal voltage and generator speed must be held constant. The information to be obtained from this test, together with that given by the other tests mentioned above, enables the various losses to be calculated, the results being shown in a series of curves representing the performance of the motor. When the power curves are to be worked up from the losses, the necessary data are obtained from the running and locked saturation curves; a speed curve is also required, and the most suitable method of obtaining this is as follows: The motor is belted to a generator of sufficient output to give the motor a 25 per cent. overload, the generator being run on a rack load, and its speed held constant throughout the test. The readings taken are those of motor and generator speeds, and amperes per phase, and from these readings a curve is plotted having total amperes as abscissæ and speed as ordinates.

Tests on a 300h.p. Three-phase Motor.

Having briefly described the practical tests it is usual to carry out on induction motors, the methods of working out the various data required to show their different characteristics from the curves obtained from the shop tests will now be considered, taking the case of a 300h.p., 440-volt, three-phase motor as an example. The running, open-circuit, and locked saturation tests of this machine were taken as already described, and the curves representing the results of these tests are shown in Figs. 2, 3, and 4 respectively. As regards the curves of locked saturation, it will be noticed that it was only possible to measure the different quantities comparatively low down on the curves, which are for this reason shown dotted for the greater part of their length. The primary and secondary currents bear

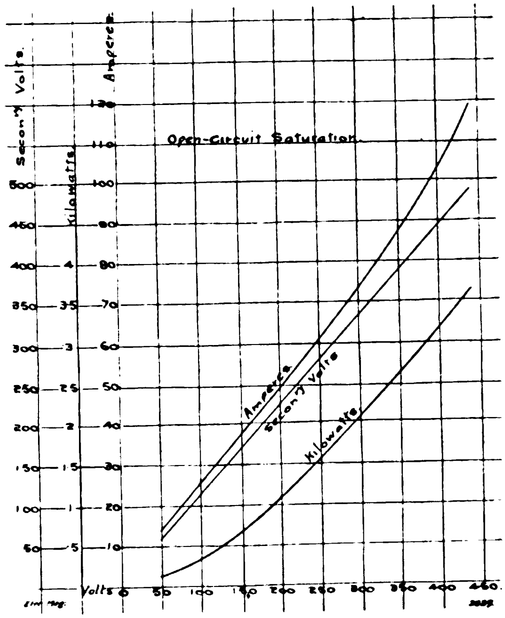


Fig. 3.

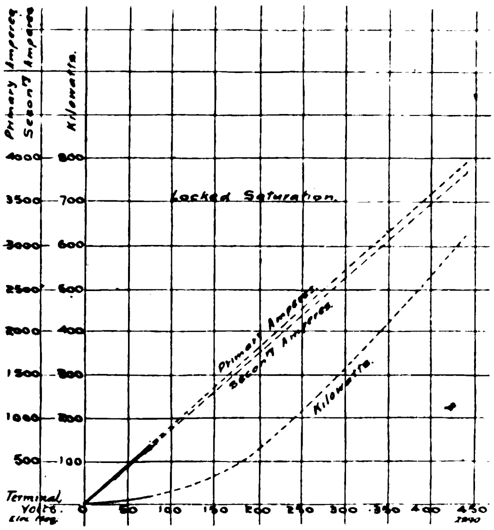


FIG. 4.

an almost straight line relation to the primary voltage, but in the case of the kilowatts curve the different points on the curve had to be calculated as follows, which gives the figures for the top point.

As is well known, the kilowatts vary as the square of the impressed voltage, and their value at 75 volts (which was the highest voltage at which readings could be taken), was 18.1 kilowatts; therefore the kilowatts at the normal voltage, viz., 440 volts, would be $= \left(\frac{440}{75}\right)^2 \times 18.1 = 34.4 \times 18.1 = 622.6$ kw. As the output of this motor was too large to allow of a brake test being made, it was necessary to work up the power curves from the losses, the various data obtained being given below:—

Resistances.

The resistance of the primary windings, taken between terminals Nos. 1, 2, and 3, at 22deg. C., was as follows:

Phase $1-2 = .0282^{\text{w}}$; phase $1-3 = .0279^{\text{w}}$; phase $2-3 = .0279^{\text{w}}$;

∴ the mean primary resistance $= .028^{\text{w}}$, and as this value must be increased by 10 per cent. to allow for the increase in resistance due to heating, its actual value will be $= .028^{\text{w}} + 10$ per cent. $= .0308^{\text{w}}$.

The resistance of the secondary winding as measured between slip rings, at the same temperature, was as follows:

Phase $1-2 = .0415^{\text{w}}$; phase $1-3 = .0421^{\text{w}}$; phase $2-3 = .0456$;

the mean secondary resistance being $= .043^{\text{w}}$.

Although it is the custom to measure the secondary resistance, this is done to serve as a check on the windings, and not merely for the purpose of calculating the secondary copper loss, as this is given by the difference between the secondary input and the brake h.p. output, but this loss may be also calculated when the secondary current is measured.

C^2 R Losses.

The formula for calculating this loss in a three-phase winding is found as follows: Let C = total current, then the amperes per phase $= \frac{C}{\sqrt{3}}$. If R = mean primary resistance between terminals, the resistance per phase will be half the resistance between terminals, then watts lost in each phase $= \left(\frac{C}{\sqrt{3}}\right)^2 \times \frac{R}{2} = \frac{C^2 . R}{6}$, therefore the watts lost in the three phases $= \frac{C^2 . R}{6} \times 3 = \frac{C^2 . R}{2}$.

Power Factor.

When it is impossible to measure the true watts taken by a motor, the power factor may be calculated from the data given by the locked saturation curves. As already stated, the current taken by a motor is made up of two components, the energy and the wattless components. The energy component of the current is in phase with the terminal e.m.f., but the wattless component lags 90deg. behind it. The wattless component consists of the magnetizing current, which is constant at all loads, and the leakage current, which varies directly with the current taken by the motor. The magnetizing current is represented by the current taken at no load at normal terminal voltage. This is taken from the running saturation curve, and its value was 114.5 amperes for

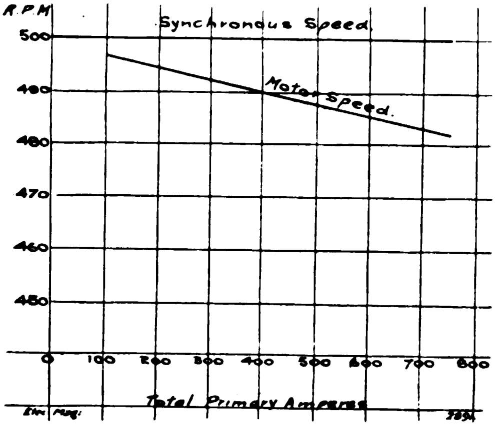


FIG. 5.

the motor in this example. The wattless or inductive component of the total apparent input is calculated in the following manner.

Referring to the locked saturation curves, read off the values of amperes and kilowatts for any particular voltage. In this example the values were 340 volts, 3050 amperes, and 400 kilowatts, then the apparent kilowatts = 3050 × 340 = 1037 kilowatts: also real kilowatts = 400.

$\therefore$ the inductive component of the apparent input $= \sqrt{1037^2 - 400^2} = 956.7$ kw.

$$\text{Inductive volts} = \frac{956.7 \times 1000}{3050} = 313.6 \text{ volts.}$$

$\therefore$ the inductive volts per ampere of primary current $= 313.6 \div 3050 = .1028$ volts.

This quantity was also worked out for 400 volts and 440 volts in the same manner, and its mean value for the different points on the curve found to be = .1035 inductive volts per ampere. At this point it is necessary to refer to the speed curve of this machine, which is shown in Fig. 5. Several different values of total amperes and their corresponding values of speed are taken from this curve, and the various losses and efficiencies, &c., are then worked out for the different load currents.

In this example the losses and efficiencies for 306b.h.p. will be worked out, corresponding to 600 total amperes and a speed of 486r.p.m. Having calculated the value of the inductive volts per ampere of primary current, the power factor of the motor when taking 600 total amperes is found as follows. As the power factor is expressed as a percentage, it will simplify matters if we express the total iron loss as a percentage; then

Total % iron loss = % inductive leakage + % magnetising current.

The % inductive leakage or inductive volts is given by

$$\frac{\text{Inductive volts per ampere} \times \text{total load amperes}}{\text{Normal voltage}} \times 100$$

$= .1035 \times 600 \times 100 \div 440 = 14.11$ % of the terminal volts.

The value of the magnetizing current expressed as a percentage of the total load

$$\text{current} = \frac{\text{Magnetizing current}}{\text{Total load current}} \times 100 = 114.5$$

$\times 100 \div 600 = 19.09$ %. Then the value of the total inductive loss expressed as a percentage $= 14.11$ % $+ 19.09$ % $= 33.2$ %. The power factor at this load may now be found from the right angle relation in a triangle of which the base represents the power factor, the vertical side representing the wattless component, or total inductive loss expressed as a percentage. This is shown graphically in Fig. 6, which is drawn to scale, and gives the power factor for this example. The power factor is also given by $\sqrt{100^2 - 33.2^2} = 94.3$ per cent.

The value of the iron, friction, and windage losses is represented by the input to the motor at normal voltage when running light, and is taken off the watts curve of the running saturation. This quantity is generally known as the "no load loss," and in this example is = 8560 watts. Having

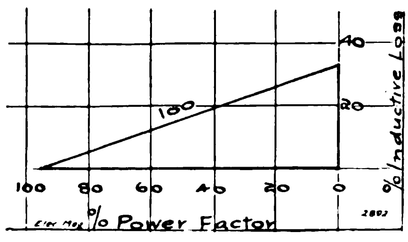


FIG. 6.

calculated the different losses, the power curves may now be worked up. The apparent h.p. =

$$\frac{\text{Total amperes} \times \text{terminal voltage}}{746}$$

$$= \frac{600 \times 440}{746} = 354\text{h.p.}$$

Also, real h.p. = apparent h.p. × power factor

$$= \frac{354 \times 94.3}{100} = 333.6\text{h.p.}$$

Real watts = real h.p. × 746
= 333.6 × 746 = 248,865.

Now the total losses include the $C^2 R$ loss in the primary winding + the no-load loss.

The primary $C^2 R$ loss =

$$\frac{C^2 . R}{2} = \frac{600^2 \times .0308}{2} = 5544 \text{ watts ;}$$

also no-load loss = 8560 watts.

∴ total losses = 5544 + 8560 = 14104 watts.

The true watts to be converted into mechanical power =
= real watts − losses = 248,865 − 14,104
∴ true watts = 234,761.

As the slip of the motor must be taken into account, the watts converted and given out as brake h.p. will be less than this quantity. The synchronous speed of an induction motor =

$$\frac{\text{number of alternations of the supply circuit}}{\text{number of poles on the motor.}}$$

Also the difference between this speed and the actual speed of the motor at any load is termed the slip, then the percentage slip is given by

$$\frac{\text{synchronous speed} - \text{motor speed}}{\text{synchronous speed}} \times 100.$$

The slip, when expressed as a percentage of the synchronous speed, is equal to the $C^2 R$ loss in the secondary winding expressed as a percentage of the total input to the secondary, because the value of the slip for any particular load on the motor is only just sufficient to generate the voltage required in the secondary windings to overcome their ohmic resistance. The synchronous speed may be taken to represent the rate at which energy is supplied to a motor, and the actual speed at which it runs the rate at which the energy is delivered, and for this reason the efficiency of a motor is sometimes taken as the ratio of the actual to the synchronous speed.

It will, therefore, be seen that the slip of the motor must be taken into account when it is desired to calculate the true value of the watts output which is converted into brake h.p. The actual value of the watts output converted =

$$\frac{\text{True watts} \times (100 - \text{per cent. slip})}{100}$$

The "slip" of the motor when developing 306b.h.p. is found by substituting the actual values of the generator and motor speeds in the formula given above; then

$$\% \text{ slip} = \frac{500 - 485.5}{500} \times \frac{100}{1} = 2.9 \%$$

∴ 100 − % slip = 100 − 2.9 = 97.1

∴ watts output =

$$\frac{234,761 \times 97.1}{100} = 227,953 \text{ watts}$$

$$\text{and b.h.p.} = \frac{227,953}{746} = 306 \text{ (nearly).}$$

The apparent efficiency =

$$\frac{\text{b.h.p.}}{\text{apparent h.p.}} \times 100 = \frac{306}{354} \times 100 = 86.5 \%,$$

also real efficiency =

$$\frac{\text{b.h.p.}}{\text{real h.p.}} \times 100 = \frac{306}{333} \times 100 = 91.75 \%.$$

Although the real efficiency of an induction motor is of greater importance from the commercial side of the question than its apparent efficiency, this latter quantity must also be taken into account, as the output of the generator supplying the power to a motor depends upon the apparent watts taken by it, and for this reason the apparent and not the real efficiency should always be used when calculating the current taken by a motor.

The torque developed by the motor is

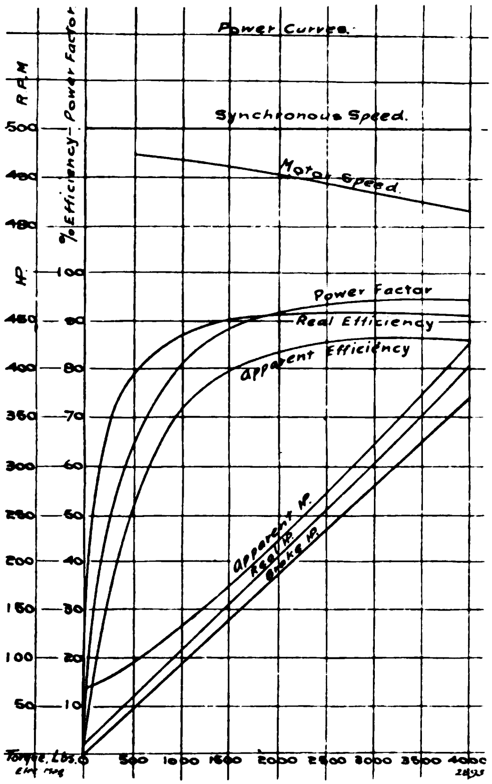


FIG. 7.

calculated from the output and its corresponding speed at full load, and is given by

$$\frac{\text{b.h.p.}}{\text{speed} \times .00019} = \frac{\text{b.h.p.} \times 5250}{\text{speed}} =$$

$$\frac{306 \times 5250}{485.5} = 3308\text{lb. torque.}$$

The torque developed is proportional to the product of the secondary current and the flux through the secondary, and, as already stated, varies as the square of the impressed voltage. Although the torque exerted depends upon the sum of the watts output and the losses in the secondary winding, strictly speaking, it cannot be said to vary in direct proportion, owing to the fact that as the speed falls off when the load is increased, and the torque varies inversely as the speed, the torque must increase more rapidly than the watts output. The pulling-out or maximum torque which a motor can develop is generally between two and three times its full-load torque. In the case of motors having wound rotors of high resistance, as the maximum torque is not reached until a motor stops, they cannot be said to exert a pulling-out torque, but with motors having a low resistance secondary, the pulling-out torque will be much greater than the starting torque. As is well known, an induction motor having a wound rotor is capable of exerting a large starting torque with a moderate starting current; in fact, this type of motor will give a starting torque equal to its full-load torque with a current slightly in excess of the full-load current.

The starting torque is found from the torque curve of the locked saturation, which gives the no-load torque at normal voltage, the value of the torque at full load being obtained from the brake h.p. curve. The value of the starting torque as compared with the full-load torque is given by no-load torque ÷ full-load torque. As the output of the motor referred to in this example was too large to allow of the no-load torque being measured, the value of the starting torque could not be obtained.

This completes the data necessary for drawing up a complete series of power curves, the values of speed, apparent and real h.p., apparent and real efficiencies, and power factor being plotted as ordinates with the corresponding values of torque as abscissæ, and the curves so obtained are shown in Fig. 7, and represent the different characteristics of the motor at all loads. So far as the accuracy of the methods employed in arriving at the various data in connection with these experimental tests is concerned, the only point open to argument, in the writer's opinion, is the method of calculating the power factor, which, although not strictly correct, does not involve any serious inaccuracy in the results of tests.

THE INTRINSIC BRIGHTNESS OF LIGHT CENTRES.*

J. E. WOODWELL.

THE importance of intrinsic brightness as a factor in practical illumination has been long appreciated and strongly emphasized. At no time has this factor been more essential from the standpoint of hygiene of the eye than the present. The opportunities for violation of the laws of hygiene have not only been enlarged, but the penalties of such abuses have been greatly augmented, with the general introduction of the recently developed lighting sources of high intrinsic brightness, such as metallic-filament incandescent lamps, flame arc lamps, and high-pressure gas lamps. In too many of the recent installations the most dazzling gas and electric lamps are ruthlessly placed in such positions that the eye cannot escape the glare. Moreover the distressing brightness of the source is often intensified by the improper use of concentrating reflectors.

Briefly any brilliant light in the field of view, however small, causes a contraction of the pupil of the eye and reduces the effect of illumination received from other parts of the visible field. A contraction of the pupil also takes place even if the bright spot is viewed only occasionally. Furthermore the continuous or occasional presence of a bright light source in the field of view impairs, temporarily at least, the sensitiveness of the eye itself, thus again reducing the effectiveness of illumination. Moreover, the contraction of the iris in the presence of bright light sources soon reaches the limit of its protective faculty, beyond which it responds feebly to an increase in brightness. The control of the pupillary aperture appears to be designed to strengthen the vision under comparatively weak illumination, rather than to protect against excessive intensity or brightness.

Recent researches of André Broca and F. Laporte† indicate that the pupillary contraction caused by bright light sources within the peripheral vision reduces visibility in proportion to the decrease in working illumination and produces the greatest eye fatigue in comparatively weak illumination. The exhaustion and injurious effect was greatly reduced on the other hand under an illumination of from 1.86 to 3.72 foot-candles, which was shown by tests to be favourable for work, taking into consideration the physiological properties of the eye and the mean limits of its accommodation.

The intrinsic brightness of the luminous source rather than the distance of the source from the eye was shown to be the principal cause for pupillary contraction. The same careful investigation also made it evident that the different light sources may be classed —with reference to their action in producing pupillary contraction and residual images—in the order of their respective intrinsic brightness.

The researches referred to above, as well as other previous investigations, do not indicate that the protective faculty of the eye is susceptible to the energy effect or to light rays of different colour. Ultra-violet rays have been regarded by some authorities as harmful, but it has been shown that these rays in the light from various forms of

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* Abstract of a paper read before the Illuminating Engineering Society, Philadelphia, Pa., U.S.A., October 5-6.

† "Étude des principales sources de lumière au point de vue de l'hygiène de l'oeil." MM. André Broca et F. Laporte. *Bulletin* of the Société Internationale des Electriciens, vol. viii. (2d series), No. 76.

incandescent illuminants of high intrinsic brightness are, with few exceptions, much less than in direct or even reflected sunlight. Other invisible radiation of much more harmful character may accompany not only the newer light sources of high incandescence but those of lower temperature as well.

The more important hygienic effects of light sources of high intrinsic brilliancy within the field of vision may then be summarised as follows :—

1. Contraction of the pupil is caused, thereby reducing the amount of light entering the eye and the consequent visibility.

2. The sensibility of the visual organs is temporarily impaired by residual images and retinal fatigue.

3. The effects of (1) and (2) are also produced by the occasional view of bright sources or by subjecting the eye to sudden fluctuations of light.

4. Intrinsic brightness rather than the distance of the source from the eye is the principal cause of pupillary contraction.

5. The harmful effects are greatest in proportion to the decrease in the working illumination and are considerably reduced under an illumination exceeding two foot-candles.

6. The different luminous sources may be classed with reference to producing pupillary contraction and after images in the same order as their respective intensities.

In applying the knowledge of the laws of hygiene of the eye to the design of artificial illumination, the best criterion of the proper values of intrinsic brightness of the light source, as well as of other essential factors, is daylight.

The intrinsic brightness of nearly all artificial light sources being so much higher than that of natural daylight is the principal cause of eye-strain and wear and tear on the visual organs. Even the most successful efforts to secure diffusion in artificial illumination by the so-called indirect method cannot be compared with the diffusion of daylight. From this point of view diffusion is the most important single quality of daylight. Diffusion may be obtained in artificial illumination by enlarging the area or surface of the light source, by shading the source with diffusing globes or screens, or by concealing the source and utilizing the diffuse reflection of the surfaces which receive the direct light.

The intrinsic brightness of a light source is the candle-power or intensity of the source divided by the area of the luminous surface. The intrinsic brightness of a small surface is the candle-power perpendicular to the surface divided by the area of the surface. Intrinsic brightness is stated, therefore, in candle-power per square inch, or in hefners per square centimetre.

Measurements taken by Basquin show a mean annual brightness for zenith sky in Chicago of 500 candles per square foot, or about 3.47 candles per square inch, with a range from 200 to 1100 candles per square foot according to the month and other conditions Making due allowance for the decrease in brightness near the horizon for natural reasons, and the reduction of the effective sky area by buildings and other local objects, the virtual intrinsic brightness of the sky in relation to the flux of light received through an ordinary vertical window under average conditions probably rarely exceeds one-fourth of the above figure. Measurements of the daylight illumination received in rooms at various distances from a window fitted with a ground-glass screen indicate also that the vertical brightness of the flux of light from the sky, direct sunlight excluded, though varying widely under different conditions, is not often more than one candle-power per square inch. Even such a comparatively low degree of brightness exposed to view affords discomfort to the eye. Shades and screens are depended upon to modify all but the most moderate natural brilliancy, so that, with a satisfactory interior illumination, the virtual intrinsic brightness of the flux of daylight through windows may be as low as 0.1 or even 0.01c.p. per square inch. Even

an abnormally high illumination of ten foot-candles on a white diffusing surface, such as white blotting paper, gives an intrinsic brightness of the surface very little more than 0.005c.p. per square inch, neglecting absorption, which would reduce the apparent brightness to 0.004c.p. or less.

Compared with such figures the intrinsic brightness of all naked artificial luminous sources is enormously high, while the values secured in actual practice by the use of shades and diffuse reflecting surfaces are generally more than ten times as great.

A number of authorities regard four or five candle power per square inch safe and admissible, and one or two candle power good practice. While the use of even the lower of these values in artificial illuminations is questioned, it would result in a most pronounced improvement from the hygienic standpoint and alleviate one of the principal causes of eye-strain and fatigue.

Acid-frosted or sand-blasted incandescent carbon or metallized-filament lamps, as commonly used in exposed positions without reflectors, have an intrinsic surface brightness of from 0.75c.p. to 1.0c.p. per square inch. When in the field of vision, however, such frosted lamps frequently produce a most distressing and harmful result, and reduce the value of the effective illumination.

In consideration of the foregoing data, as well as from actual experience in the design of illumination, it is the opinion of the writer that from 0.2c.p. to 0.1c.p. per square inch is none too low for the safest and best practice where artificial sources must necessarily be placed in the constant or even occasional field of vision. The use of such a factor is necessarily dependent upon the local conditions, and especially upon the intensity of general illumination of the objects viewed and the corresponding pupillary aperture, as noted by Broca and Laporte.

In the presence of a highly illuminated field of view, the iris diaphragm of the eye is "stopped" down almost to a minimum, and the direct effect of any light sources within the field of vision is correspondingly lessened. These conditions occur in practice where a room or space is almost uniformly illuminated by exposed lighting sources of high brilliancy and there are neither dark surfaces, sharp contrasts, nor shadows which would require the eye to work with a larger pupillary aperture. Such conditions, while tending to reduce the deleterious effect of brilliant light sources, are not the most favourable for best vision. Working in such an environment it is not strange that a comparatively high intensity of illumination in foot-candles is frequently demanded and the eye appears insatiable. From the standpoint of efficiency, therefore, as well as of hygiene, the conditions must favour a pupillary aperture which is sufficiently large to work the eye at its maximum sensibility. To accomplish this result the intensity of illumination should not only be moderate, in general from 1.5 to 4ft. candles, but the intrinsic brightness of the sources should be reduced to 0.2c.p. or 0.1c.p. per square inch; or else the sources must be completely excluded from the field of vision.

With a weak illumination, however, requiring the eye to work at or near the limit of opening of the pupillary aperture, the eye is extraordinarily sensitive to the direct light from sources of even moderate intrinsic brightness, and under such circumstances the actual apparent surface brightness of the source cannot be kept too low for safety. This point is illustrated by the distressing effect of frosted and shaded lamps, and sometimes of candles, in the field of vision under the conditions of a weak general illumination frequently found in theatres, churches, and auditoriums.

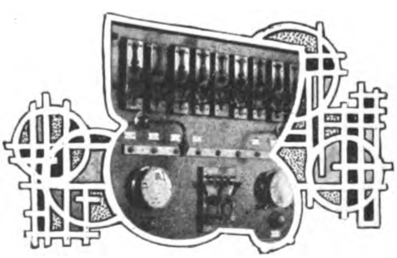
It is possible that the effects of over-stimulation by means of varying intrinsic brightness has some such relation to the pupillary aperture through the range of accommodation of the eye as that of the ability of the eye to note a constant fractional difference in luminosity through a wide range of intensities of illumination, according to the law of Fechner.

The distance of the luminous source from

the eye within the limits ordinarily found in interior illumination does not appear to be material, except in its relation to the position of the source and its inclusion or exclusion of the field of vision.

The preceding discussion has been confined to the direct effects and modification of the intrinsic brightness of luminous source, but it is evident that the same conditions will apply equally well to the reduction of the intrinsic brightness of all illuminated surfaces which become secondary sources of illuminations. Even with indirect illumination the ratio of brightness of the reflecting surfaces to that of the illuminated field may be excessive.

The foregoing data will have their principal application, however, in the design of globes and shades which are commonly employed to reduce the intrinsic brightness of exposed lighting sources. In arriving at the resultant intrinsic brightness it is necessary to refer to the spherical candle-power of the source, and to make allowance for the absorption by the glass, which may vary between from fifteen to twenty-five per cent. for alabaster, to sixty per cent. or more for opal or porcelain glass. The absorption by ground glass will vary according to the process employed in roughing or sand-blasting, but it will generally be between twenty and forty per cent. The thickness as well as the quality of the glass will also have a marked influence upon the absorption. Moreover, the distribution of the light from the source will be modified by surrounding the lamp with an enclosing globe. The most perfect diffusion will be received by a ground opal glass, but at a sacrifice of from forty to sixty per cent. of the total light. The more transparent glasses, on the other hand, do not sufficiently diffuse the light from the source. In any event, however, it is important that the size of the diffusing globe or shade should be proportioned to the candle-power of the source, so that the reduction of intrinsic brightness will be approximately uniform. Fittings in which the design employs exposed frosted lamps together with other lamps in large enclosing globes of comparatively low intrinsic brilliancy are especially objectionable.



A SERIES OF COMPARISONS BETWEEN ELECTRICITY AND GAS.

R. E. NEALE, B.Sc.(Lond.).

I.—For Lighting Service.

So much has been said regarding the relative merits of gas and electricity, and such apparently *conclusive* statistics, proving the superiority of each in turn, have been successively advanced by their respective advocates, that the enumeration of the factors to be considered may aid in obtaining a clear view of the case. So many local and indirect influences bear on the issue that a *total* comparison is almost impracticable. The following article is, however, intended to present the matter as completely as possible.

Both electricity and gas are now emerging from an era which has seen remarkable developments. A few years ago carbon lamps (3.5 watts per c.p.) using electricity at 8d. per unit were equivalent to gas at 3s. 2d. per 1000 cubic feet. Then came incandescent gas, revolutionising the position. Now, with the advent of high-efficiency glow lamps, the demand for high candle powers and the extended use of electricity, the latter is rapidly regaining its position.

As is well known, practically any efficiency *can* be obtained with either gas or electricity by sacrificing mantles and lamps and by using specially treated gas in the first case and over-running the lamp in the second.

The writer wishes merely to state the results he has gathered with regard to ordinary working, and to tabulate a few of the costs of the various high-efficiency illuminating sources now available. The comparative costs of installation and various fittings are also given, and the relative costs of gas and electricity over a given number of hours are calculated at specified charge rates and assuming lives found to be about correct by the author. In a separate section the relative convenience and other general merits of electricity and gas are considered: these factors have no *direct* monetary value, but their indirect effect is enormous, and they have undoubtedly commercial value in influencing the installation of the various systems.

It may be wondered how so many sets of data, all apparently equitable and authenticated, can give such conflicting conclusions. On considering the influencing factors, the probable source of discrepancies is obvious. In comparing gas and electricity we may collate:—

1. Cost of installation and fittings.
2. Cost of renewals (dependent on life of burners, mantles, and lamps).
3. Efficiency during life.
4. Cost of current or gas per 1000c.p. hours (depends directly on 3).

Now, from tests made at laboratories above suspicion, the efficiency and deterioration of efficiency during the life of mantles and lamps are well known; the costs of electrical energy and gas are quite definite; the cost of installation fairly definite; and hence the point on which, no doubt, all differences arise is that of *renewals*, and it is on this point that the author wishes particularly to lay stress.

The inducements, now so varied in nature, offered by different companies, gas and electric, to their consumers, are considered quite separately. Many comparisons have been made assuming that electricity is cheaper, in that free wiring is allowed; or gas, in that stoves are lent free, and so forth; but it seems to be quite an ignored fact that

whatever the initial reduction made to the consumer, the cost thereof, *plus interest*, must inevitably recoil on him if the company is to continue solvent. This charge is usually made by an increase in the cost for 1000 cubic feet or per b.t.u.

To avoid all complications it will be assumed that the consumer pays a normal price for his installation in both cases. The standing charges, to cover interest on the capital outlay of the station, mains, &c., gas or electric, is included in the charge per unit to the consumer. Hence it is assumed that he pays for: (1) meter hire, (2) full wiring or piping, (3) all lamps—bought at the ordinary retail prices. [In some cases the company provides them at cost price or contracts for their maintenance at a certain rate per quarter. Such arrangements must be classed as "inducements."]

In this article only lighting by gas and electricity is compared, the branches of varied domestic uses and of power applications being reserved for separate theses. By these reservations gas will lose nothing in the present comparison, for the advantages of electricity in all "odd" domestic service and in power applications are conclusively demonstrated in a later section.

The subject of street and shop lighting is also treated more fully in a separate article, this being rather a distinctive field of enterprise. Certain comparative figures between gas and electricity for high c.p. units are given, but as it is in ordinary domestic uses, if anywhere, that gas has its superiority, this service is examined in detail. For high c.p. illumination, the flame arc is the most efficient source of artificial light known (c.26 watt per c.p.), being within reasonable distance of the sun efficiency (approx. 0.10 watt per c.p.—from Kelvin's data).

Various patent gases—mostly the vapours from certain oils utilised by air pressure, carburettion, atomization, or volatilisation—are largely advertised now, but to examine all these would require a huge volume. The special plant required for most of these illuminating agents quite precludes them from use in towns or villages and only makes them applicable to private country house lighting, which again is best undertaken by an electric generating plant owing to the facilities for then driving agricultural tools, hay-cutters, &c., by electric motors.

If, as in many cases, water power be available on the estate (the common country mill pond and race serve excellently) there can be no doubt as to the superiority of electricity over a "patent" gas plant. If no such power be available the most economical procedure is usually to erect a suction producer gas plant supplying a gas engine direct-coupled to a generator. The economies effected by electrically operating many agricultural tools are very considerable.

The advent of high-efficiency glow lamps has considerably reduced the size of plant necessary to obtain a given amount of light. The usual practice in such private sets as the above is to provide a battery of storage cells capable of taking the whole night load after 9 to 10 p.m., and of taking the peak of the day load.

Advocates of coal-gas lighting assert that it is cleaner, cheaper, and in every way superior to all "patent" gases. Be it so, it only remains to prove that electric light is preferable from every point of view to coal-gas, to at once include all its gaseous rivals.

One of the great advantages of the use of electric light is the ease with which a consumer can with a little care greatly reduce his cost per unit. This point (referred to again later) is especially applicable to the maximum demand system. In many cases the economy effected is almost incredible (in a particular instance the "flat" rate = 4d. per unit, by a judicious use of the mean demand system the mean charge over a year's supply = 2.8d. per unit).

Again, a consumer can in some cases adjust his operations so as to take no current from the mains during the "peak" period of the station. Where this is so he can frequently secure his current at little more than half the prices otherwise chargeable.

Taking into account the various systems of charging and the great possibilities of economy without inconvenience, the author has found that as a mean of the charges in a number of districts in England, Scotland, and Wales a fair lighting rate is 3d. per unit, while energy may be bought at 1d. per unit for heating and cooking. These mean charges take into account the economies possible with the maximum demand system, and hence are treated as flat rates in the present comparison. In many areas a cheaper supply can be obtained—thus in Hampstead, with a peculiarly uneven demand, the mean rate per unit over a period of more than one year = 2.93d.

As an average taken in *the same districts* (and not in other districts where the charges are much higher owing to the absence of electrical competition) the author finds 2s. 9d. per 1000 cubic feet a fair gas rate. This is a flat rate, and is the same for both heating and lighting (at once a disadvantage as compared with electricity).

The statement that the gas rates are higher where no electrical energy is available and that gas companies feel the competition of electricity very strongly is justified by the immediate reduction of gas charges wherever electricity supply is commenced. A striking example of this was given in London in June, 1906, when a certain gas company, admittedly by force of electric competition, reduced its rates by

> 10 per cent. on accounts of £10 and under, and by
>
> 22½ per cent. on accounts of £50 and over
>
> (the original price being 2s. 11d. per 1000 cubic feet).

Even for power use the gas companies, in the districts mentioned above, only reduce their charge by 1d. per cubic feet on the average. This again indicates that the gas companies have reduced their charges to the lowest possible limit—an indication verified by the fact that no maximum demand charges, &c., exist in gas lighting. The fact that electricity can be bought at much reduced rates when taken *steadily*, proves that, in the course of a few years (station loads continually increasing and becoming more diverse), the load on generating plant will be so uniform that rates will still further decrease, and, more consumers being obtained in consequence, the charges will fall still lower, and so on till a minimum is reached, which can even now be prophesied as not exceeding ½d. to ¾d. per unit.

This change has been demonstrated in the past, the charge of the early small stations, with few consumers and very uneven load, being 8d. to 10d. per unit, which charge is now reduced to a mean of 3d. per unit. A similar reduction will occur in future, and *at least* the present power rates must soon be available for lighting.

Under these new conditions electricity will be far the cheapest source of illuminating energy. Even gas engineers admit that electricity is cheaper than gas, if current can be obtained at 1½d. per unit. The figures below indicate the superiority of electricity even at 3d. per unit.

In the present article only incandescent gas lighting is compared with electric lighting, not even the most strenuous gas advocate being able to advance figures making flat flame gas burners "in the running" with electric lamps.

In many cases gas is compared with the cheapest grades of carbon lamps, and in the case of one authority writing a book in 1907 the existence of any more efficient electrical source of light than the carbon lamp at *four watts per c.p.* was absolutely ignored. (Even carbon lamps have been available at 3.0-3.5 watts per c.p. for many years.) Obviously this is unfair, since metallic-filament lamps of about four times the efficiency are on the market and can be used by anyone desirous of reducing his bill. No doubt the initial expense is greater, and, unfortunately, many people still cannot see the final economy. However, this short-sightedness is fast disappearing, just as the objection to incandescent gas on account of the higher cost of

mantles than the old fish-tail burner is no longer heard.

For the purpose of the present comparisons — between electricity and gas for domestic lighting and for high c.p. lighting—without here making reference to the arrangement of the lights and reflectors in the two cases, the following subdivisions are convenient:—

1. Inducements, whether automatic or deliberately offered by electricity and gas companies to persuade consumers to take up their respective supplies.
2. Cost of installation.
3. Cost of use in (*a*) domestic lighting, relatively low c.p.'s; (*b*) high c.p. lighting, dealing with the relative merits of arc lamps and the high-pressure gas system. These costs are taken to include only the cost of current or gas and of new mantles, lamps, or carbons as the case may be.
4. Convenience and risks.
5. Health.
6. Indirect costs.

Further sections as: (1) the general application of electricity to various uses in which it is impossible to employ gas; (2) Private Installations—(*a*) for simple lighting, (*b*) for power and lighting—are to be dealt with later, the latter subject especially involving many new considerations.

Inducements.

As already mentioned the inducements offered by companies are very varied and in some cases apparently very liberal. As however the consumer has eventually to pay for them, this temporary liberality is not of much value to him. It is of interest however to note what temptations are offered.

The only real advantage that can be offered by a company and which the consumer does not ultimately pay for is that of supplying mantles or lamps at prices = cost + expense of handling. This system has the disadvantage of discouraging local retail traders.

Many companies, gas and electric, offer free meters. In this connection the gas company in a certain London district provided free meters till quite recently, but in making a nominal reduction in the charge per 1000 cubic feet *imposed a rate of 2s. 6d. per quarter on the meter!*

Free stoves are lent in some cases, while totally or partially free wiring or piping is a common inducement. In some districts free lamps or mantles are provided for six months or one year.

One gas company at present entices gas-engine users by the munificent promise of *a slight reduction in the cost of piping.* In pleasing contrast to this are the electric power rates, which are seldom more than one-third to one-half the lighting rates. Many supply authorities also take into account "modifying circumstances" in relation to the further cheapening of the supply in individual cases. [These "modifying circumstances" are never used as a means of raising certain consumer's rates above the normal published charges—such would, of course, be an opportunity for much unjust treatment.]

Under the heading "Inducements" may fairly be included notes on the possibilities of cheapening supply.—

As regards gas supply these possibilities do not exist. Gas can never be sold at appreciably lower rates than those at present in force. In the case of electric supply, however, quite a different state of affairs exists. Current for "power" can already be obtained at ¾d. per unit in many areas, and it is only a question of the extended and general use of electricity before all current can be supplied at this rate. This is no mirage, but a plain solid fact. Companies are not likely to supply millions of units per year to "power" users at rates unprofitable to themselves; hence once a large steady demand is obtained it will be possible to supply all consumers at equally low rates.

Under these circumstances electricity would be incontrovertibly cheaper for domestic lighting, as shown below, in the

actual current plus lamp charges apart from the indirect economies already applicable. Constancy of demand is what is required for economy in supply, one particular example of this being the case of public stair or street lighting; owing to the constancy of demand over long periods these are always supplied at much reduced rates. As pointed out later "power" consumers are already allowed a large amount of lighting at power rates.

In the case of gas lighting no such reduction of charges is possible. It will be urged, no doubt, that gas consumers get a certain uniform rate whether their demand be uniform or irregular. This is a certain advantage at present, but as the use of electricity extends, this advantage will decrease more and more rapidly. The *normal* price of electricity is about ¾d. per unit under the present system of generation, providing constant generation in large quantities can be utilised. In the course of a few years this will be practically the flat rate charged to all consumers. For the present, however, owing to the smaller number of consumers on the mains, preference has to be given to those with the steadiest demand.

In connection with the steadying of demand on the station, an interesting scheme recently came under the writer's notice. Outlining the bare essentials of the scheme, it was proposed to install in every "light consumer's" premises a number of secondary cells which should charge from the mains during the day and be used at night to take off the peak of the consumer's demand, so equalising the station load and keeping down the consumer's maximum demand.

The consumer when installing would advise the company of the number of lights he required and of the probable value of his "peak" load (or the company would estimate this for him). Such a number of cells would then be installed as would give the most uniform demand on the station during the twenty-four hours, working on the above system. The cells would be switched in to charge at a certain hour, and automatically switched out when their e.m.f. rose to the full value. Switching in could be effected by an inexpensive clock-work switch, saving the consumer all trouble The switch-out relay is a well-known device already in use. The company would fix the hours of switching-in of various districts so as to secure an even load. The loss to the consumer by the temporary storage would be quite compensated by the less charge per unit consequent on his more uniform demand. The storage loss is very small, the efficiency of even cheap cells being well over 90 per cent., especially on such a regular and short-period cycle as the present one. The demand in the evening would come on the cells till the current taken exceeded that which the cells could supply continuously for five hours (if this be the mean duration of the evening requirements). After this point the mains would be switched "on;" otherwise the cells might take the peak, the mains supplying the normal load. This latter arrangement would necessitate fewer cells, but the former keeps the battery in continual service, so preserving its condition much better. The company would send a competent man to inspect the cells, say once a week. By allotting different days to different districts one man could supervise an immense area and the inspection costs per consumer would be quite nominal. This system, the bare outlines of which have been sketched, offers many possibilities, though in a few years' time it is hoped that all necessity for such load-regulating devices will have vanished.

It would appear that the switchgear required would be very expensive. Hence this opportunity is taken of deprecating the high prices imposed by many electrical manufacturers on their goods. This applies to all electrical fittings. These charges affect public opinion very prejudicially with regard to the use of electricity. On several occasions the writer has made mechanically operated trip switches to break circuits carrying 10-12amp. from a few inches of stiff copper wire appropriately bent. It is not urged that any such devices should be employed

in this connection, but the example proves that much of the cost of automatic switchgear is unnecessary. For general adoption in domestic service cheap yet reliable apparatus must be devised. There is no inherent impossibility in this provision, and, until it

Costs of Installation.

(*a*) DOMESTIC LOW C.P. UNITS.

ITEM NO.	ELECTRIC.		GAS.
1	2s. 6d. per quarter.	Meter hire.	2s. 6d. per quarter.
2	¼d.-½d. per foot.	Wiring, piping.	½d. per foot.
3	1d. per yard.	Beading to cover wiring.	See note below.
4	1s. 6d.	Tumbler switch (electric).	—
5	—	Pneumatic switch (gas).	3s.
6	—	Bye-pass to gas burner.	1s.-1s. 6d.
7	9d.-1s.	Lamp-holder; burners.	3s.
8	1s.	Ceiling "box"; ceiling adaptor.	1s.
9	Notes below.	Shades for lamps.	Notes below.
10	As in "running costs"	Lamps; mantles.	As in "running costs" section.
11	5s.	Plainest wall bracket.	5s.
12	15s.	Ditto, with some pretence to beauty.	£1
13	£2.	Chandelier.	£2-£3.
14	£1 10s.	Hall chandelier.	£2
15	£1-£1 10s.	Table standard.	£1-£2.
16	½d.-¾d. per foot.	Flexible wire for ditto; flexible tubing.	4d. to 6d. per foot.

Points to be noted with regard to the above items are:—

(1) In many towns electric meters are cheaper than gas meters.

(3) The cost of this beading is purely nominal, and allows electric wires to be run along walls without inartistic effect, whereas gaspipes would have to be embedded.

(9) The cost of shades is, of course, quite indeterminate, and varies entirely with individual taste. As explained later, far more artistic effects are possible with electricity than with gas, and for the same outlay a prettier globe effect can be obtained with electric than with gas lighting.

(11-15) The costs of chandeliers, &c., are taken from lists supplied by special request. The charges do not include lamps and globes (but do include lamp-holders and internal wiring) in the case of the electric fittings; in the case of the gas fittings, globes and burners are ***not*** included.

Again, the superior artistic possibilities of electric light are to be noted, and, apart from the cheapness on this score, electric chandeliers are appreciably cheaper, because their joints have no longer to be gas-tight, and no taps have to be fitted.

(16) The price for flexible tubing is as quoted by the Welsbach Company.

(*b*) HIGH C.P. UNITS.

Proceeding just as before:—

ITEM NO.	ELECTRIC.		GAS.
1	As in (*a*).	Meter, &c.	As in (*a*).
2	2½d. per foot.	Wiring; pipes.	1d. per foot if lead; 2d.-3d. per foot if for high pressure.
3	See notes below. £8.	Open arc lamps.	Refers to standard makes of these various lamps; c.p. varies from 700c.p.-4500c.p.
4	£6.	Enclosed arc lamps, D.C.	
5	£4-£5.	Enclosed arc lamps, A.C.	
6	£4.	Small "indirect" arcs.	See notes below.
7	12s.	Line resistance.	
8	£2.	Automatic cut-out & compensating resistance	
9	£1 10s.	Safety coil.	
10	£3.	Transformer.	
11	£1.	Strain release arc lamp coupling.	
12	10s.	Winch and pulleys.	
13	9s. per 100 feet.	Rope for ditto.	
14	3s. 6d.	Hanging insulator (weather proof).	
15	2s. 6d.-3s. 6d.	Ceiling adaptor.	2s. 6d.-3s. 6d.
16	15s.	Switch (electric).	—
17	—	Long distance bye-pass (gas).	30s.
18	—	1200c.p. Welsbach lamp, no mantles, &c.	£15 15s.
19	—	Accessories for slinging or mounting ditto.	£2-£3.
20	—	Three or five mantles (200 hours).	3s. 9d. or 6s. 3d.
21	£3 to £9 (see notes below).	1000ft. arc carbons.	
22	£20 (£10-£30).	Projectors (depending essentially on electric arc).	—

Treating these items as before:—

(2) Piping for specially high-pressure gas is very expensive to manufacture and instal.

(3-5) These prices are not to be taken as showing the relative costs of open, enclosed, d.c. and a.c. arcs, for the candle-powers of the sizes chosen are not equal. The prices are those of the most commonly used sizes of each type.

(6) These small "indirect" lamps are fitted with reflectors (£4 complete), and are very suitable for small shop lighting.

(7-10) It is obvious that in no one installation will all these accessories be required. Where a large number of arcs are run in series, the automatic cut-out and compensating resistance device is advisable, but in other cases the line resistance (No. 7) or the safety coil (No. 9) suffice, according as the supply is d.c. or a.c. (10) The transformer is only necessary or advisable on a.c. systems of high voltage where a single lamp is required to be run without the losses consequent on series resistance or inductance.

(11-13) would apply equally to gas lighting were it possible to suspend gas lamps thus. Such suspension is not possible, however; the arc lamp can be lowered for retrimming and cleaning, but no such facility is present in gas lighting. The fact that the lamp can be lowered makes higher standards and more efficient light distribution possible with arc than with gas illumination.

(19) The accessory fittings and mountings for the standard lamp (item 18) would certainly total to £2-£3.

(21) The price of carbons per 1000ft. is a very variable amount, depending entirely on the type of lamp and nature of service: this is gone into more fully in the next section of this paper, but it may be noted that 1000ft. of carbons cost on the average 60s. to 180s., the hours of burning obtained being between 6000 and 20,000, according to the quality of carbon and type of lamp (open or enclosed, &c.).

(22) The candle-power of the projectors referred to is about 10,000c.p. on the average.

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is made, the popularity of electricity will correspondingly suffer.

Cost of Installation.

It is extremely difficult to compare the costs of installation in an equitable manner, since the standard of workmanship and the decorative results demanded vary so much in individual cases. So many things are possible with electric light which are quite unobtainable with gas, and the realisation of these improvements is accepted as such a matter of course when installing electric light, that the fact that much more is being obtained than when fitting up the "corresponding" (?) gas system is often overlooked. Owing to these extra luxuries the cost of installation may be higher in the case of electricity than in the case of the far plainer gas equipment.

This being so, the preceding schedule has been prepared with the object of retaining as nearly as possible equivalent installations. The table is divided into two sections as shown, and a few remarks thereon are appended:—

Cost of Use—Running Costs.

It is the cost of actual use, the cost per 1000 c.p.-hours of illumination, which is the criterion most generally looked to when comparing the cost of various sources of light. That many other factors must also be referred to is shown in the present article, but it will be well to deal with this section at considerable length since it is in this connection that mis-statements are usually made.

The sources compared in Table I. are:

1. 16c.p. Welsbach burner.
2. 16c.p. carbon lamp.
3. 25c.p. tantalum lamp.
4. 40c.p. Osram lamp.
5. 55c.p. Nernst lamp.

The efficiencies for each source are as equitable as possible while the lives assumed are those found by the author to be typical. The current and gas charges are 3d. per b.t.u. and 2s. 9d. per 1000 cubic feet respectively as already explained. The costs for lamps and mantles are the *nett retail* prices quoted by reliable firms on special request.

No doubt the life of the mantles will be challenged and numerous exponents will put forward remarkable figures for mantle life. Under carefully guarded conditions it is of course possible to keep a mantle intact for longer periods than those assumed here, just as in a test laboratory a glow lamp can be kept of good efficiency even after 2000-3000

hours life. The writer has taken a careful average of mantles in use in all possible positions, in domestic service in all parts of the country and denies that the average life exceeds 200 hours. It is, on the face of it, impossible to maintain mechanically intact for long a mantle which is a mere ash, and a remarkably fragile one at that. It may be said that to a certain extent a carbon filament is also an ash, but the difference between a carbon filament which when new is as springy as steel and which will withstand continuous service on tube trains (surely the acme of rough service) for months on end, and the ordinary Auer mantle, merely the skeleton of an impregnated silk thread, no more homogeneous in nature than the latter and possessed of none of its toughness and tensile strength, is unquestionable. What incandescent mantle, such as is commercially possible for domestic use, could live for an hour or even five minutes on a tube train at full speed? True, specially strong mantles have been made for street service, but as shown below their high price (1s. 3d. each) at once places them on a level with carbon lamps as regards initial cost, and even then their life is very brief. The cost of certain specially strong mantles is 1s. 6d., but their life in rough service is very erratic.

Metallic filaments are considerably superior to carbon filaments mechanically as well as electrically, so that the advantage over gas mantles is still further evident in this case. As showing the remarkable mechanical properties of tantalum, the following test may be mentioned:—A diamond drill set to work at 5000r.p.m. on a block of tantalum had only penetrated ½mm. after continuous operation for five days and nights.

It will be seen from Table I. that Nernst lamps are cheaper than gas for domestic lighting (if the body of the Nernst be reckoned as equivalent to the gas burner, and only the Nernst "burner" and the gas mantle be compared). Tantalum and Osram lamps run the incandescent gas very close indeed, but are at present seriously handi-

TABLE I.—GAS TAKEN AT 2s. 9d. PER 1000 CUBIC FEET.

Source.	Initial Cost.	Mean Life.	Mean C.P.	Efficiency	Watts per hour or cubic feet per hour.	Cost per 1000 hours and per 1000 c.p.-hours. B.O.T. Unit, 3d.				B.O.T. Unit, 1.5d.				B.O.T. Unit, 1.00d.			
						Current or Gas per 1000 hrs.	Renewals	Total.	Total per 1000 c.p.-hours.	Current or Gas per 1000 hrs.	Renewals.	Total.	Total per 1000 c.p.-hours.	Current or Gas per 1000 hrs.	Renewals.	Total.	Total per 1000 c.p.-hours.
Welsbach Incand.	4½d.	200 hours	16	15c.p. per cubic foot	1.07 cubic ft.*	35.3d.	22.5d.	57.8d.	3.61d.	As before		—	3.61d.	As before.			3.61d.
Carbon	10d.	1000 ,,	16	3.25 watt per c.p.	52 watts	156d.	10	166	10.40	78d.	10d.	88d.	5.5d.	52d.	10d.	62d.	3.88
Tantalum	1/10	1000† ,,	25	1.7 watt per c.p.	42.5 ,,	127.5	22	149.5	6.00	63.75	22	85.75	3.44	42.5	22	64.5	2.58
Osram	3/6	1000† ,,	40	1.1 watt per c.p.	44 ,,	132	42	174	4.35	66.0	42	108	2.70	44	42	86	2.15
Nernst	5/- (entire ½a. lamp.)	800 ,,	55	0.9 watt per c.p.	49.5 ,,	148.5	64.5	213	3.88	74.25	45	119.25	2.17	49.5	64.5	94.5	1.72
,,	1/6 (burner only)	800 ,,	55	0.9	49.5 ,,	148.5	22.5	171	3.10	74.25	22.5	96.75	1.76	49.5	22.5	72	1.31

† Usually considerably exceeded.
* This is a moderate estimate to continually give 16c.p. As a rule, the falling off in c.p., and hence the decrease of mean efficiency, is more marked than assumed here.

capped by their great initial cost (which is being rapidly reduced). Recent tungsten lamps give appreciably higher economy than Osram lamps.

The extra renewals costs due to "accidents" is far greater with incandescent than with glow lamps, for the merest touch breaks a mantle.

In Table I. a modest life (1000 hours) has been taken for the electric lamps. Many new metallic-filament lamps do not blacken, and have a useful life of over 2000 hours. In such a case, for instance, the Osram cost, with b.t.u. costing 3d., would be only 3.82d. per 1000 c.p.-hours. Again the lamps dealt with in the table are of low c.p., and, for practically the same price, much higher c.p. lamps can be obtained, these possessing the advantage of being more robust still, the cost per 1000 c.p.-hours being correspondingly diminished.

The actual cost in any particular case can easily be estimated thus :—

(*a*) For Gas : Cost per 1000 c.p.-hours =

$$\left[\left(\text{Initial mantle cost} \times \frac{1000}{\text{life in hours}}\right) + \left(\frac{\text{C.P.}}{\text{efficiency}} \times 1000 \times \text{cost gas per 1000 cubic feet}\right)\right] \div \text{C.P.}$$

(*b*) For Electricity : Cost per 1000 c.p.-hours =

$$\left[\left(\text{Initial lamp cost} \times \frac{1000}{\text{life in hours}}\right) + \left(\text{C.P.} \times \text{efficiency} \times \text{cost per b.t.u.}\right)\right] \div \text{C.P.}$$

(Note the distinct senses in which efficiency is used in (*a*) and (*b*), viz., in (*a*) efficiency = c.p. per cubic feet per hour, while in (*b*) it = watts per c.p.)

On the $1\frac{1}{2}$d. and 1d. rates, electricity is shown to be by far the cheaper. It will be objected that these rates are not yet in force. That is so, but the writer is aware of numerous districts in which the average price is already 2d. per unit; in the Newcastle district it is less still. Every new electric consumer now aids towards the reduction of charges, as has been instanced in the past; whereas gas has reached its limits of economy, electricity is on the eve of vast cheapenings in supply. Large turbo-generators and very diverse loads lead to remarkable efficiency.

The present electric consumer pays very little, if any, more in direct payments to the supply company than does the gas user, and, when the health and cleanliness factors, &c., dealt with later, are considered, he pays far less in gross cost.

The fact that gas cannot be supplied at rates lower than those already existing is proved by the fact that in numerous coal districts even in large towns and villages, and where electric competition is present, the charge is 2s. 9d. to 3s. 6d. per 1000 cubic feet. 3s. 6d. per 1000 cubic feet is no uncommon charge for gas: on this basis the Welsbach burners cost 4.22d. per 1000 c.p.-hours. It may be said that the efficiency of the mantle given is too low, but by careful tests the writer has found that 18c.p. per cubic feet is a good average efficiency for a *new* mantle, and, as is apparent to every gas consumer, the c.p. rapidly falls, the order of the decadence being, in fact, about 50 per cent. in the course of a few hours. The statement made by some makers that the c.p. of a mantle has been known to keep its full value for 12 to 18 months is ridiculous and wilfully misleading. It has been repeatedly shown that a very serious drop of c.p. occurs within a few hours as a rule. In some cases the limit becomes days, in others minutes.

The extreme sensitiveness of the mantle to local conditions is a point remarked by every user. No matter how carefully a mantle be fitted or by whom fitted, about 20 per cent. develop some flaw (*e.g.* a crack at the bottom or a hole blown in some point of the mantle) during the first night's use, and fully 50 per cent. during the first week. After that it is merely a question of chance as to how long the mantle lasts.

Passing down what has been claimed by gas engineers to be the best lighted street in the world, the author noted that fully 20 per cent. of the mantles (high-pressure system) had more or less serious breaks or rents. The gas companies themselves warn consumers of the poor efficiency to be obtained from a mantle damaged thus. Fully half the mantles in the street referred to were only partially incandescent over the top third of their height.

The decrease in efficiency of mantle with the slightest drop in supply pressure is extraordinary, and in the analogous electrical effect (variation of c.p. with supply volts) the new filament lamps are far superior to carbon owing to their having a positive temperature co-efficient of resistance.

The increasing use of metallic-filament lamps will further decrease their initial cost (the present cost is only one-third to a quarter the price at which they were first issued) and so make the use of electricity indubitably cheaper in every item and not only as a whole.

(*To be continued.*)

A GERMAN VIEW OF THE FUTURE OF METALLIC-FILAMENT LAMPS.

The popularity with which the 60c.p. or high-power metallic-filament lamps have been received indicates that the people in general are in favour of units of greater illuminating intensity than the carbon filament, 16c.p. lamp. The Osram lamp of about 32c.p., says Mr. H. Remané in a recent issue of the *Elektrotechnische Zeitschrift*, will take the place of the 16c.p. carbon lamp, especially when it is remembered that the cost of installing a certain total candle-power is reduced as the candle-power of the unit increases.

He does not agree with the opinion expressed by a number of recent writers, who believe in the future of the 220-volt metallic-filament lamp. Undoubtedly the higher-voltage lamp is less efficient than the 110-volt lamp, and experience has shown that if the 110-volt lamp works at one watt per candle-power, the 220-volt lamp will require, for the same length of time, a constant supply of about one and one-quarter watts per candle in sizes of 40c.p. to 100c.p. Nor does the writer think that the lamp-makers' skill will bring about any considerable percentage of increase in either the life or efficiency of the 220-volt lamp, because of the fineness of the filaments, which prevents their being safely handled in quantities, the inevitable variations in diameter, and other mechanical difficulties which enter into the construction of the higher-voltage lamps. The economies introduced in the wiring system by the higher voltage are hardly likely to reduce the cost of current sufficiently to effect a commercial competition with the 110-volt lamps, with their slightly more expensive system of wiring.

*THE ELECTRICAL EQUIPMENT OF CRANES.**

J. B. DUCKITT.

THE adoption of electricity during the last fifteen years as the motive power for driving the various motions on cranes has led to considerable improvement in the efficiency of this class of machinery, and has been a source of greater economy in the handling of materials and an important factor towards increasing the output in many works.

Among the principal advantages claimed for electrically-driven cranes the following may be mentioned :—

1. The high efficiency of the electric motor, and the improvement in the design of gears, has tended to increase the overall efficiency.
2. The crane is only absorbing power when actually doing work, and then only in proportion to the actual work done.
3. Increased safety, as such appliances as clutches, palls, sliding gears, &c., are entirely dispensed with, and the brakes are—in the majority of cases—entirely automatic and quite independent of the crane-driver.
4. Greater flexibility, as each motion is self-contained, with its own motive power, and can be worked over a large range of speed in conjunction with, or independent of, the other motions.
5. Higher speed of the various motions is possible, as the transmitting of power to the motors entails no serious complications, the limiting factors being reduced to the size of motor and controller permissible.

Against these claims must be placed the extra cost and upkeep of the electrical equipment, which requires a certain amount of attention to keep it in efficient working order, but this has been materially reduced by the recent improvements in the design of electric motors and controllers, and since electrical manufacturers specialized plant more particularly for crane work.

Speed of Cranes.

There has been a marked tendency during the last few years to increase the speeds of the various motions. Though advantageous in some cases it has not always proved wise, and is a point which requires careful consideration. In the first place, higher speeds necessitate the fitting of larger motors; this means an increase of the starting current, which tends to lower the total or all-day efficiency, and is also liable to affect other motors on the installation. Again, larger motors take longer to attain maximum speed, and where the total height of lift, length of travel, length of traverse, or angle of slewing is small, the motor may never reach its maximum speed or only attain it for a very short period of the total time the motion is working, resulting in a reduction of the efficiency and considerable waste of current in overheating the resistances.

Further disadvantages are the greater strains which are thrown on the crane and gantry, the difficulty of obtaining satisfactory controllers for very large motors, and the excessive wear and tear to which they are subject when constantly working on overloads. Another important factor in considering the speeds of the various motions is the class of work to be dealt with by the crane, a low speed often proving more economical where delicate and careful handling of parts is requisite.

* Abstract of paper read before the N.E. Coast Institution of Engineers and Shipbuilders, Nov. 20, 1908.

Owing to the very large number of conditions which are met with in the various types of cranes and class of work to be handled, it is impossible to lay down any hard-and-fast rule, but a careful review of the various points mentioned, and an approximate estimate of the average distances through which each motion will be required to work, will generally form a basis leading to satisfactory results.

Motors.

It is essential that the motors should be of strong design, mechanically as well as electrically, on account of the severe conditions they have to withstand by constant reversing and overloading, and the excessive speed to which series motors are liable through carelessness when lowering.

All crane motors are subjected to variable loads—the average load being often less than 50 per cent. of the full rated load. It is therefore essential that the fixed losses should be small and the I^2R or variable losses large, as motors designed in this way have a high efficiency over a large range of load, the full-load efficiency being less than in the case of motors intended to work at or near full load, and which should have high fixed losses and low I^2R or variable loss (Fig. 1). To obtain this result they should be fitted with armatures having a large number of turns and a magnetic circuit designed on generous lines.

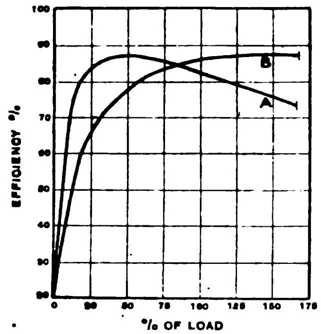
Though shunt motors were adopted at first and are occasionally fitted to-day, the series motor has been almost universally employed on account of its wide range of speed and torque, and also the loss due to field excitation—increasing with the square of the load—is a component of the variable losses which increases the efficiency at light loads.

The totally-enclosed type of motor has proved the most suitable for crane work, as dirt and damp are excluded and the electrical portions are effectively protected from mechanical injury. The disadvantages of this type are that the output is lower than with an open motor, the radiation of heat from the outer casing being relied on to keep this within normal limits. A further objection is that slight faults developing in the electrical portions of the motor cannot be observed, and often serious damage ensues before attention is drawn to them; but the advantage gained by the absolute protection of the electrical parts of the motor undoubtedly outweigh these defects.

Armature shafts should be designed on more liberal lines than for ordinary motors, owing to the heavy torsional strains to which they are subjected by being constantly reversed, and the heavy overloads and excessive vibration to which they are liable. The bearings should be of gunmetal or phosphor-bronze and provided with efficient self-lubrication. Where the diameter is increased, they can be safely made much shorter than is the usual practice: this is sometimes an important advantage, as the over-all length of the motor is reduced and often results in a more compact design of crab.

Slotted armatures with former windings are now universal and are particularly suitable for crane motors, as the mechanical strains are transmitted to the teeth, and dragging of the winding on the core—which was a frequent source of trouble in the days of smooth-core armatures—cannot take place; they also afford considerable protection to the winding from external injury and can be easily and quickly repaired.

Two-circuit or series winding should be adopted for the armatures, because inequality in the lengths of the air-gaps, or eccentricity of the armature in the field due to wear of the bearings, does not affect the satisfactory running of the motor, as equal voltage is induced in both circuits of the armature; whereas with multiple-circuit or parallel winding, unless the armature is truly central in the fields, the various sections of the winding will have unequal voltages, and heating and sparking will result. In two-circuit windings, only two sets of brushes are required, though in large motors the adoption



CURVE A.—LOW FIXED LOSSES AND HIGH VARIABLE LOSSES.
CURVE B.—HIGH FIXED LOSSES AND LOW VARIABLE LOSSES.

FIG. 1.

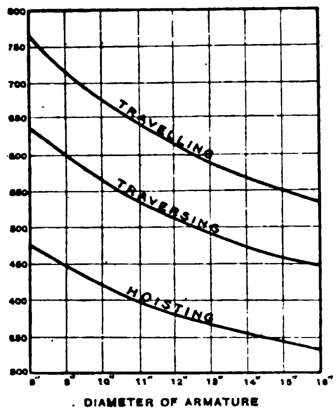


FIG. 2.

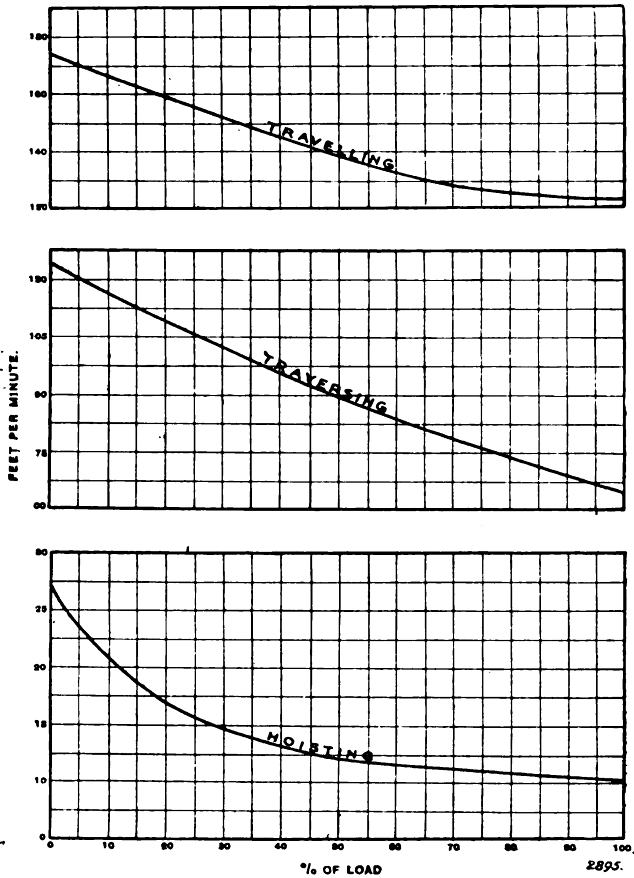


FIG 3.

of extra sets tends to reduce the reactance voltage and eliminate sparking.

Commutators should be large in diameter and have ample brush surface to cope with the overloads and assist the radiation of heat; they should also have a large number of sections, in order to keep down the reactance voltage and allow of fixed brushes for all loads.

Too much care cannot be taken during construction to ensure perfect balance of the armature and commutator, or serious and destructive vibration will result.

The design of the brush-holders should be simplified as much as possible and the number of screws, nuts, springs, and parts liable to work loose, reduced to a minimum. Brush-quadrants when fitted should be very firmly secured; a good method, in the author's opinion, is to fix the brush-holders direct to the end cover, connection being made to them from the outside, and flexible leads going through the casing—which are a frequent source of trouble—dispensed with altogether.

Except in very small motors the cases and bearings should be split to enable the armature being taken out with the least possible trouble and in a minimum of time.

Rating of Motors.

The output of electrical machinery is governed by the permissible temperature rise, and for continuously running plant is based on a specified rise of temperature in a specified time, usually 40deg. C., or 75deg. F. rise for a period of six hours' running under full load; the machine is also designed so

that the radiation of heat at this load is equal to its generation, enabling it to be run continuously under full load without any appreciable further increase of temperature. Crane motors only run intermittently, and then only under full load for very short periods, and would never approach the specified temperature rise if they were designed on the above lines, but would be very much larger and more costly than is necessary. A different basis has therefore to be adopted, the settling of which has been the cause of considerable difficulty and controversy.

The b.h.p. of the motors necessary for the various motions can be calculated with a fair amount of accuracy, but the exact conditions of load under which the crane will have to work is a variable factor which is seldom known before the crane is installed, and the rating of the motor has to be decided purely by experience. This has led to the adoption of a similar plan to that used for traction motors, in which the b.h.p. is based on a specified rise of temperature for one hours' run under full load; as the conditions are somewhat similar in crane motors—particularly on travelling and traversing motions—but the periods of rest of much longer duration, most makers of crane motors specify the b.h.p. of the motor on a continuous run of one-quarter, one-half, or one hour for a specified rise of temperature. This method, though convenient, has not always proved satisfactory, particularly in the case of one-quarter hour rated motors, as the rise of temperature due to overloading—which is proportional to the square of the current—increases very rapidly in the armature and field-coils and they burn out before it has had time to spread to the other portions of the motor. It is therefore inadvisable to adopt motors of less than one-half hour rating except in very special cases where the actual conditions of working are definitely known.

Another system of rating motors for intermittent work, called the "load-factor" method, has been adopted by Messrs. Siemens Bros., and claims to give a more suitable size of motor than by basing them on a time rating of one-half or one hour. The factor of most importance in selecting a motor for intermittent work is the ratio between the working and idle periods, or the ratio between the working period and the time occupied for a complete cycle of operations; this latter ratio is termed the "load-factor." Load-factor =

$$\frac{\text{Time the motor is working under full load.}}{\text{Time the motor is working + Time the motor is standing.}}$$

The maximum period of time occupied for a complete cycle of operations must also be taken into consideration when deciding this "load-factor." In the case of cranes handling regular loads and having a certain specified cycle of operations, it is possible to obtain these figures with a fair amount of accuracy, but in the majority of cases, as, for instance, overhead travellers for engineering works, no definite cycle of operations can be specified, and it is necessary to adopt an arbitrary basis. Messrs. Siemens find that basing the output of the motors on a twelve minutes' cycle gives satisfactory results, as it is obviously correct for shorter cycles and not materially affected by cycles of longer duration. "Load-factors" are expressed as $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, and so on, and mean that the motor is running under full load for $\frac{1}{2}$, $\frac{1}{3}$, or $\frac{1}{4}$ of the total time occupied for a complete cycle of operations. With a twelve minutes' cycle we get the following relations between the working and idle periods of time for various "load factors":—

"Load factor"	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{1}{8}$
Time the motor is working	6	4	3	2	$1\frac{1}{2}$ min.
Time the motor is resting	6	8	9	10	$10\frac{1}{2}$ min.

The motors are designed to give the specified temperature rise when run intermittently under full load for six hours at the various "load-factors," that is, at $\frac{1}{4}$ "load-factor" the motor would be run under full load for three minutes out of every twelve minutes, the test extending over a period of six hours.

The advantages of this method of rating motors are that the varying conditions of the respective motions are taken into consideration, the "load-factor" for travelling and slewing motors in which the variation of the load is small and always at or near full load, being in most cases higher than for hoisting and traversing motors, in which the average load seldom exceeds fifty per cent. of the full normal load; with "load-factor" rating only a knowledge of the actual conditions of working is necessary, whereas with "time-rating" the heating of the various sizes and types of motors, which is a very variable quantity, must be taken into account.

Speed of Motors.

In deciding the most suitable speeds for the motors, the speed at full load has not only to be considered, but also the acceleration of the armatures at light loads on the various motions. The curves in Fig. 3 show the approximate increase in speed of the hoisting, travelling and traversing motions from full load to light on overhead travelling cranes. It will be noticed that the ratio of speed increase for the hoisting motion is about 3 to 1, for the traversing motion 2 to 1, and 1.5 to 1 for the travelling motion.

It is essential that the "no-load" speeds should come well within the safety limit, or serious damage to the motor may result; this is particularly important in the case of the hoisting motor, as the speed when lowering with load may be much higher than when hoisting light, and unless some system of controlling the speed of lowering is adopted, the prevention of serious damage is left entirely to the discretion of the crane-driver. As the "no-load" speed is a definite quantity which cannot be increased in the case of travelling and traversing motors, it is obvious that they can safely be run at much higher speeds than in the case of the hoisting motor. In Fig. 2 the writer gives curves showing the maximum speeds for various diameters of armatures and for the various motions which have been found satisfactory.

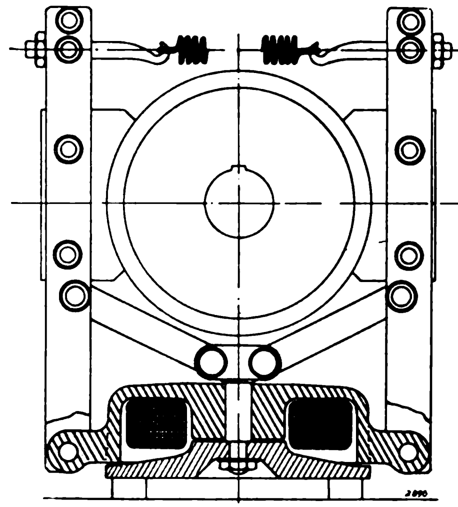


Fig. 4. Magnetic Brake by Lancashire Dynamo and Motor Company.

Brakes.

The hoisting motion of all cranes should be fitted with a reliable brake of sufficient power to bring the maximum load to rest when lowering, and also absorb the kinetic energy of the armature, gearing, &c. The electrically-released brake is particularly adapted for this purpose, as it is switched in and out of circuit with the motor, and is quite automatic; it is also simple, compact, and safe, as any stoppage in the current supply causes its immediate action. Electrically-released brakes are usually fitted on the motor spindle, and may be divided into two classes—magnetic and solenoid.

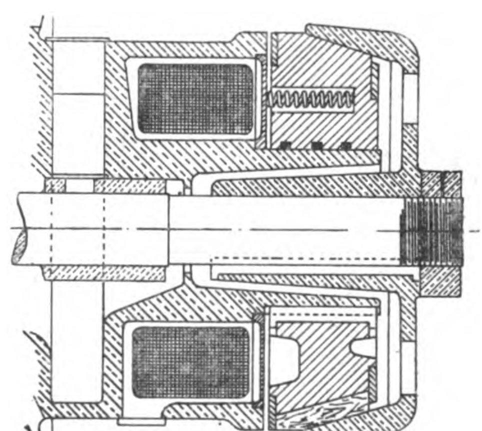


Fig. 5. Magnetic Brake by Dick Kerr & Co.

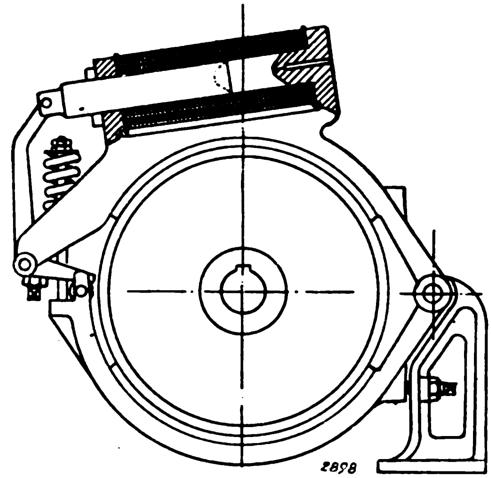


FIG. 6. SOLENOID BRAKE BY SIEMENS BROTHERS.

In the magnetic type the brake is released by the attraction between a keeper and an electro-magnet, the pull of the magnet being utilised to oppose the pressure exerted by powerful springs and release the brake. Examples of this type are shown in Figs. 4 and 5. It is very compact and powerful, but the gap between the magnet and keeper, or the distance of travel, is necessarily small, otherwise a very powerful and costly electro-magnet would be required; it also needs careful adjusting, for should the gap become too great owing to wear, the brake will not be released on light loads. An advantage claimed for this brake is that when the current taken by the motor is very low, as when lowering with load, the keeper is released, applying the brake, and thus tends to check acceleration. Although this may be of some advantage when the power to be dealt with is small, it cannot be utilised with heavy loads on account of the heating and excessive wear of the brake which would result.

The solenoid type is based on the well-known principle of the coil and plunger, and though the attracting power is not so great as in the magnetic type, the plunger has a much longer travel, and is usually connected to a lever carrying a suitable weight, to the other end of which is coupled the brake arms or strap. As it is important that the action of the brake should be smooth and steady, it is essential that this type should have a dashpot connected with the plunger to prevent hammering and shocks to the motor and gear when it is released. Figs. 6 and 7 show typical examples of this type of brake.

Brake coils are either shunt or series wound. When shunt wound they involve extra contacts in the controllers and extra wiring on the crane, neither are they so safe as when series wound, as they constitute a separate and distinct circuit which may

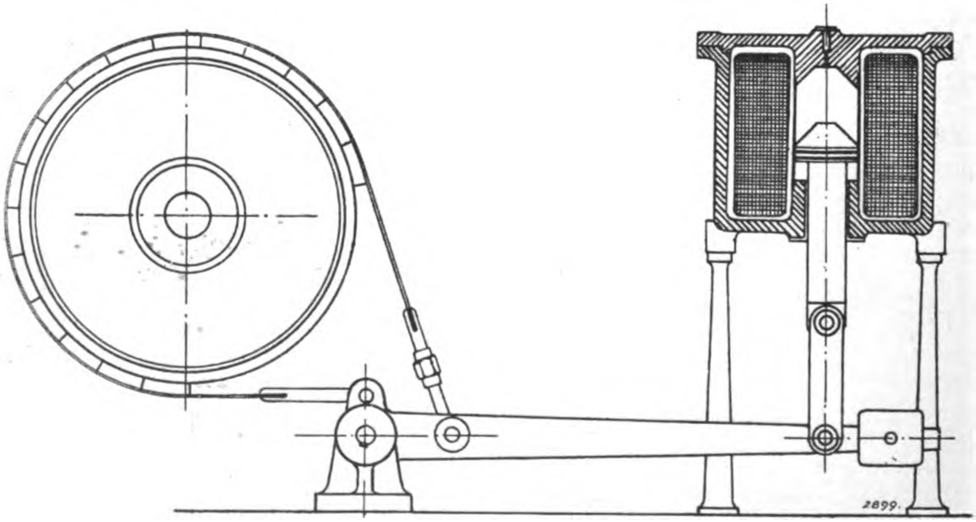


FIG. 7. SOLENOID BRAKE BY JOS. ADAMSON & CO.

break down irrespective of the motor circuit. They also require a parallel resistance to take the inductive discharge when breaking the circuit, and unless provision is made for cutting this out, it is a source of continuous waste of current while the brake is in action. The brake magnets and coils should be designed to release when starting with light loads, but at the same time care has to be taken that they do not release too soon or the load may start lowering. The author has found it best to design the brake so that it will release when the magnetic pull on the armature of the motor is sufficiently strong to hold the load. An efficient arrangement should be provided for easily adjusting the brake and taking up the wear, especially when the magnetic type is fitted.

Controllers.

The controller consists of a combined starting, reversing, and regulating switch. It is essential that its design should be mechanically and electrically sound, so that it can be handled by inexperienced men without sustaining or causing damage or throwing undue strains on any portion of the equipment; it must also be efficient and operate the various motions smoothly and without jerking or jarring. The effort necessary for its operation should be small, and the construction strong, simple, and durable, and all parts standardised and easily renewable, to reduce maintenance cost and repairs to a minimum. The section and number of contacts should be sufficiently large to cope with overloads or starting current without heating or excessive sparking. Controllers of the liquid, face-plate, and drum or tramway type, are largely used for cranes, each finding numerous adherents.

Liquid controllers are a combination of a liquid starting and a metallic reversing switch. This type has found favour with many crane makers on account of its cheapness; it is also simple to design, and there is no sparking and burning of contacts, the circuit being made and broken in the liquid. The disadvantages are the difficulty of obtaining satisfactory regulation owing to the polarisation of the plates, the necessity of short-circuiting the tank to cut out the resistance entirely and prevent serious loss in efficiency, the difficulty of effectively insulating the tank, and the objectionable use of a solution of chemicals for the liquid, on account of the corrosion it is liable to cause by coming in contact with electrical connections, &c. The percentage of chemical in the liquid should be carefully regulated for different voltages or sudden rushes of current will occur when starting or short-circuiting, throwing severe shocks on the equipment and gearing. Another objection is that where large power motors are used the tank becomes very heavy and lumbersome if built on sufficiently broad lines to keep down the heating of the liquid.

In face-plate controllers the contacts are usually in the form of rings mounted upon a base of slate or other incombustible and insulating material, connected in such a manner as to form a combined regulating and reversing switch. The large number of contacts possible in this type gives a greater subdivision of the resistance and tends to smooth starting and better regulation of the motor; the switch is also mounted in the case containing the resistance, the whole being self-contained and very compact; no exterior connections are required except those necessary for connecting between the controller and motor. The leading objections to this type are the difficulty of fitting an effective blow-out, also the contacts and contact arms are not usually enclosed; but where it is imperative both these objections can be surmounted with little difficulty.

Drum or tramway controllers have been largely adopted for cranes, as they are particularly suitable where motors are subject to frequent reversals and for intermittent and variable loads. They consist of a number of insulated contact fingers arranged separately in a row and fixed to the casing. The starting handle or lever is rigidly connected to an insulated drum

which is free to revolve and on which are secured contact strips, the relative position of these and the connections between them being so designed that as the drum is revolved (either clockwise or counter-clockwise) it makes the requisite connections between the various contacts. The advantages claimed for this type are that it is totally enclosed and has no current-carrying parts exposed, a powerful magnetic blow-out can be easily and effectively fitted, and owing to its particular form of construction the various connections for different systems of control can be more easily carried out. The leading disadvantages are that few regulating steps in the resistance can be fitted or the controller becomes unnecessarily large, the resistances are not self-contained and necessitate a large number of leads between the controller and resistances.

Resistances for crane controllers should be so designed that the maximum speed of the motor is attained as quickly as possible without the starting current being excessive, the current peaks being so graded that they are equal on the various steps. In order to obtain this result it follows that the various sections of the resistance must be in the form of a geometrical progression, the extremes of which are the total resistance necessary and the resistance of the motor, which are known quantities. In deciding the total resistance necessary the governing factors are the required range of speed of the motor and the nature of the work to be done; a resistance suitable for a travelling motor which has only a small range from minimum to maximum load would obviously be quite unsuitable for a hoisting motor which requires careful regulation over a wide range of load. Generally the maximum starting current ranges from 1.5 to twice the normal full-load current, and the hoisting motor resistance is designed to give a reduction of from .3 to .6 times the normal full-load current, according to requirements, on the first step. For traversing, these figures are usually .5 to .6; and for travelling and slewing, .5 to .75. It must not be overlooked that reducing the current on the first step also reduces the sparking, which is an advantage in many cases. Fig. 8 shows the development of the resistance for a 20b.h.p. hoisting motor at 250 volts.

Controllers, like motors, are designed for intermittent working with due regard to the starting current and taking into consideration that the crane has only to deal with full load occasionally. It is found that doubling the capacity of the controllers for continuous rating, and making the period of work to period of rest as 1 : 1, and the time limit from two to five minutes for resistances, will

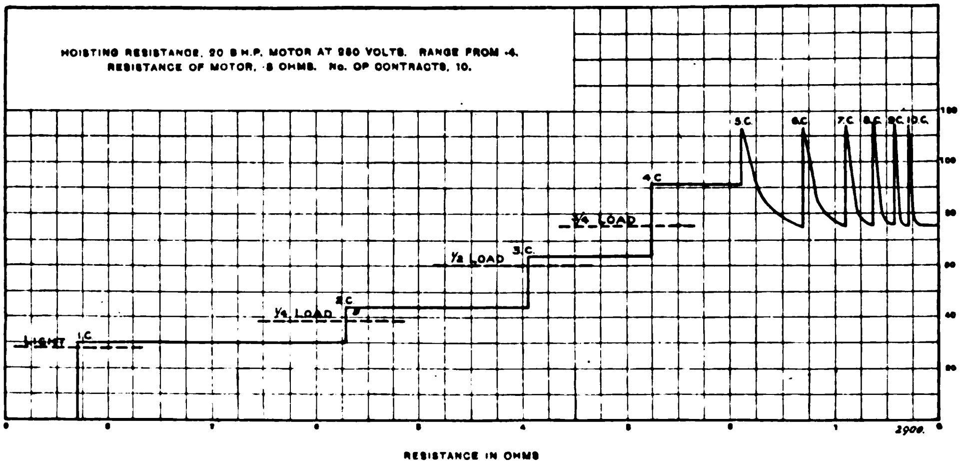


FIG. 8. DIAGRAM OF DEVELOPMENT OF HOISTING RESISTANCE.

generally meet the requirements for crane work satisfactorily.

Electric Braking and Control of Lowering.

Mention has already been made of the danger of the speed becoming excessive and even dangerous when lowering with load, and the characteristic of series motors to accelerate with light loads materially helps to increase this tendency; it has therefore been found necessary to fit apparatus whereby this acceleration can be effectively checked, and various mechanical and electrical devices are adopted.

Control by means of mechanical brakes does not come under the heading of this paper, but a summary of leading types and their qualities may prove interesting.

The ordinary brake controlled by hand or foot lever in the cage relies totally on the discretion of the crane-driver. The governor safety-brake is controlled by a spring governor fitted on the motor spindle, so arranged that when the speed exceeds the maximum permissible, the balls on the ends of bell-crank levers fly open and apply the brake; this brake can only be used for comparatively small loads or the heating and wear become excessive. Automatic or load-brakes are frequently fitted on heavy-load cranes, and usually consist of a number of friction plates keyed alternately to the shaft and casing of the brake, or a flat spiral coil connected to the shaft and working on the inside of a drum which forms the casing. When hoisting, these brakes are locked and revolve with the spindle, but, when lowering, the casings are locked and prevented from turning by means of a ratchet and palls, the friction between the revolving and fixed parts constituting the brake, the pressure on the friction surfaces being regulated by the load. It is essential that the load should exert more holding power on the brake than is requisite simply for holding the maximum load, in order that power will have to be exerted by the motor to drive it down, or no checking of speed will result. Further disadvantages are the difficulty of efficiently lubricating the brake and dissipating the heat, their large cost of fitting and excessive wear, and the power they often absorb when lowering light loads or the hook—which frequently reaches fifty per cent. or more of the normal full-load current—and consequent reduction of speed.

The use of mechanical brakes can be obviated by so designing the electric controller that the energy exerted by the load falling is used to convert the motor into a generator, the electric power so developed being absorbed by short-circuiting it through the whole, or varying portions, of the resistance. This method of lowering gives complete control over the speed with light or heavy loads, does not throw excessive strains on the gearing, is much cheaper than fitting governor or mechanical load-brakes, and only necessitates the use of the simple electrically released brake for holding the load. The objections to this system are that it increases the rating and cost of the motors and resistances, the controllers are more complicated, and a certain amount of care is necessary in some cases when switching back to the "off" position, or excessive sparking will take place at both the controller and commutator of the motor; the brake coil must be shunt wound and is to a certain extent independent of the motor, as explained earlier, and it is necessary at the commencement of lowering to pass current from the mains through the circuit to lift the brake magnet and excite the field of the motor; also special stops must be provided with current from the mains to drive the hook and very light loads downwards. It is likewise obvious that there will be no braking effect except when the motor is in motion. When desired this method can be applied to the traversing, travelling or slewing motions; the controller is then designed to have a braking effect in both directions, doing away with the necessity of fitting mechanical brakes.

Shunt motors have been fitted on the hoisting motion of cranes, and advantage

taken of their regenerative action when lowering, the current generated in the motor when working as a dynamo being put back into the mains instead of wasted in heating up the resistances as in the electrical braking method. Though giving complete control over the speed of lowering, materially reducing the wear and tear of brakes and tending to economy in current consumption, this method lacks the wide range of speed and torque of the series motor, which are of paramount importance when hoisting, and increases rather than decreases the rheostatic losses when starting to hoist with load.

Methods of Increasing Efficiency.

The rheostatic method of control is always adopted for crane motors; though simple, effective, and reliable, it is wasteful, as a large amount of power is dissipated by the resistances in the form of heat. When using motors which are frequently started and stopped this becomes a very important factor and materially reduces the over-all or all-day efficiency; further, when a large range of speed is required, as in the case of foundry cranes which must be capable of running at very low speeds, extra resistance is introduced to give the increased regulation and the over-all efficiency is still further reduced. So far as the author is aware, very few attempts have been made to surmount this difficulty, though the adoption of suitable modifications in the electrical apparatus would in some cases decrease the loss.

Unfortunately the series-parallel method of control cannot be adopted for the hoisting motion on cranes, as when hoisting with load the motor would have no inertia to assist it over the transition points when changing from series to parallel; but in cranes requiring a large speed range the system could be utilised to some extent by using a motor fitted with a double armature, a special throw-over switch being provided for putting these two armature windings in series when slow speeds are required and in parallel for higher speeds. In the case of travelling motions for large cranes, or cranes requiring a large speed-range for this motion, the ordinary series-parallel control could be adopted, as the conditions are almost identical with ordinary traction work; the objection to fitting two motors is surmounted by fitting one motor with a double armature, and, if requisite, double field windings. Generally only a small power motor is required for the traversing motion, but in cases where it exceeds 20b.h.p. the same remarks apply.

In the author's opinion the adoption of motors with compound field windings for hoisting motions, controlled in such a manner that when hoisting they act purely as series motors with the shunt winding entirely cut out, and, when lowering, as shunt motors with the series windings cut out, and the regenerative effect utilised, would, in most cases, give an ideal system of control for this motion; it results in a certain amount of economy in current consumption, would give absolute control over the speed of lowering (the shunt winding being designed to give a definite minimum speed of lowering with regulation for higher speeds), the use of double armatures coupled in series or parallel would not be prevented, the rating of the resistances would not require increasing as in electric braking methods of control, and no difficulty would be experienced in designing suitable controllers. The disadvantages are that the size and cost of the motor would be somewhat greater on account of the extra field windings and higher rating, it would be necessary to drive down the hook and very light loads by passing the main current through the armature as in electric braking, the solenoid brake would have to be either shunt or compound wound (in the latter the main current passing through the series brake coil being utilised to release the brake, and the shunt coil in series with the shunt coils of the motor need only exert sufficient power to hold the brake), a discharge resistance in parallel with the shunt windings is necessary to utilise the inductive discharge, and the wiring of the crane would be a little more complicated.

The author carried out some preliminary experiments with this method of control about two years ago on an existing travelling crane, which were very satisfactory, but unfortunately the system has not been fitted on a large crane in such a complete form that reliable tests over a considerable period could be taken.

Wiring Details.

The size of cables or wires for the various motions can safely be based on 1500amp. per square inch for normal full load. Cables should have an insulation resistance of not less than 600 megohms, and be protected against oil and dirt by running them in steel conduit or iron piping which has been cleared of all internal roughness and burrs, fitted with fibre ferrules at the outlets.

A main double-pole enclosed switch of strong construction should be fitted in the cage for isolating the entire crane. Enclosed fuses should be provided at the feeder ends of the longitudinal wires and also fixed in the cage for protecting each motor circuit, the latter being rated to blow at not more than twice the normal full-load current of the motor they control. As it is common practice to use one main return from the motors on the crab, a single-pole enclosed fuse should be fixed on or near the collector plate in the return lead from each motor, and rated from 10 per cent. to 25 per cent. higher than the fuses in the cage for their respective circuits. The fuses protecting the travelling motor circuit can both be fixed in the cage. Circuit-breakers, though more costly, are in many respects preferable: they ought also to be enclosed and rated in a similar manner to fuses. When a common return is used a circuit-breaker protecting it can be fixed in the cage and rated proportionately in place of the fuses on the crab.

Both sliding and trolley contacts are used, but the former give more satisfaction on overhead travelling cranes, as the grit in most works causes trouble with the trolleys; they are also more efficient and suitable for circuits below 440 volts. The contact shoes

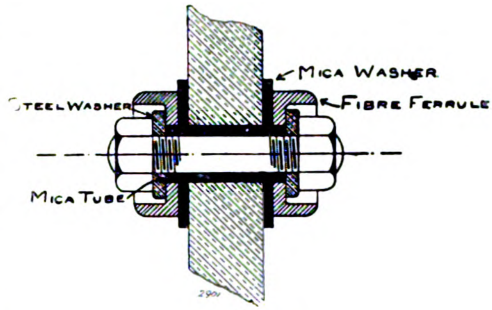


Fig. 9.

should be of soft gun-metal and easily and quickly replaceable.

Switches for the prevention of overwinding should be fitted on all cranes to break the circuit when the block reaches a minimum safe distance from the barrel. Limit-switches are also sometimes used to prevent the travelling and traversing motions from running against the stop-blocks, but they are objectionable when it is desired to work the crane as near as possible to the extreme limit of these motions; they should be enclosed and only break the current in one direction and not prevent its being run in the reverse direction. It is an advantage when the motion in running back again automatically closes the switch.

Nothing but porcelain or mica is permissible for insulating purposes; fibre should never be used except as a further protection to the insulating medium, in which case it will often prove useful and effective when insulating bolts or studs which are connected to current carrying apparatus. Fig. 9 gives an example; the mica is used as the insulating medium, and the fibre ferrules prevent oil and dirt from bridging it and causing a burn-out.

Polyphase Equipment.

So far the writer has confined his remarks to continuous-current apparatus, but polyphase motors are frequently used and can be made to operate cranes satisfactorily, though they lack the chief characteristics of continuous-current series-wound motors, which are particularly suitable for this work, and

more nearly approach those of the shunt-wound motor.

The leading advantages claimed for the alternate-current motors are their simplicity and the absence of commutators and brushes, which until recently were a serious drawback to continuous-current motors, but a better knowledge of the causes of sparking and improvements in design have almost eradicated this objection, and to-day it is possible to obtain motors which will withstand the most severe conditions of load without excessive sparking at the commutator.

One of the most objectionable features of the polyphase motor is the low value of its starting torque per ampere input; even when starting with light loads they take a high current, which is still further increased when starting under load. In order to reduce this the following methods are generally adopted:

(*a*) Auto-transformers, or compensators, are fitted in the stator or primary circuits.

(*b*) Resistances are inserted in the rotor or secondary circuits.

In the former the squirrel-cage or short-circuited type of rotor is retained and there is a complete absence of sliding contacts in the motor, which is undoubtedly a great advantage but is somewhat lessened by the extra cost of the compensators and their liability to be a further source of trouble. The winding of the rotor in the latter method necessitates the use of slip-rings and collecting gear, which are as undesirable and need quite as much attention as a well-designed commutator and brush gear; it also reduces the efficiency and overload capacity and increases the heating of the motor.

At light loads the load-factor of polyphase motors is very low; this reduces the total or all-day efficiency of the hoisting and traversing motions.

Polyphase motors have a practically constant speed over their entire range of load, and the only satisfactory method of varying it is by the introduction of resistance in the rotor circuits; other methods either decrease the torque of the motor or are complicated, expensive and unsuitable for crane work. When lowering with load the conditions with an A.C. motor are similar to those of a shunt-wound continuous-current motor, and care must be taken to switch the controller over and cut out the resistance quickly or the load may attain a dangerous speed and cause serious damage. In order to get the best results it is essential that the frequency should be low and the speed of the motor as high as possible, whereas it is particularly important that the latter should be low for cranes.

The proper sphere of the polyphase motor is where constant speed, normal torque, and high speed are requisite, but when variable speed, high starting torque, and low speeds are desired the series-wound continuous-current motor undoubtedly excels.

THE APPLICATION OF ELECTRICITY TO COLLIERY WORK.

GERALD HOOGHWINKEL, M.I.E.E., M.I.M.E.

(*Continued.*)

Electric Pumping.

One of the first applications of electric power to the driving of mining plant was the electrically driven mining pump. The disadvantages of steam as a direct motive power are obvious if one only considers underground pumps and shaft sinking pumps, with long and leaky steam ranges, obstructing the shaft to such an extent that shaft or pipe repairs become exceedingly difficult without stopping the pumps. These disadvantages, together with the high cost of the steam installation and the heavy repairs, served to give the first impulse to the use of electricity in the underground workings of collieries. The writer proposes for the present to deal with the underground pumps only, because they are quickly superseding surface-engines, and show the many advantages of electric driving to a greater extent; although the benefit to be derived by using electricity for surface work is in no way diminished.

It will not be necessary to repeat the disadvantages of placing steam-driven pumps underground, where the use of steam and the increase in temperature always constitute a danger. In the deep workings of the future the use of steam-driven pumps for underground work will be an impossibility.

The only types of pumps available, until recently, were slow-speed ram, piston, or bucket pumps according to the lift required; but on account of the shorter strokes and smaller masses to be moved, underground direct-driven steam pumps were worked at higher speeds than surface pumps. However, even these comparatively slow speeds were not very suitable for coupling to electric motors without the use of gearing. As gearing was thought to be objectionable by many mining engineers (a prejudice which is not shared by the writer), the electrical engineer was asked to reduce the speed of his motor to such a point that two of the great advantages of electric motors, *i.e.*, cheapness and small dimensions, almost disappeared. The writer has installed many geared pumps of large dimensions, and they are running satisfactorily and without undue noise. For small pumps, belt driving with high-speed motors which show a high efficiency at various loads, may be used, particularly in pump rooms where the atmosphere is not too much saturated with moisture.

The desire to use high-speed motors resulted in the design of high-speed pumps, such as the Reidler, the Bergman, and several others, using mechanically aided valves operated by levers, cams, or eccentrics. These high-speed pumps were to be used for high lifts, but lately the speed has been reduced so as to enable absolute security from breakdown owing to valve troubles, &c. For pumping plant, especially at mines, safety from breakdown is the one and only condition which must be satisfied before everything else, even before high efficiency, and, as will be seen later on, the electric motor has been instrumental in bringing into favour a class of pumping machinery which fulfils this condition, and so far has been rarely used for underground pumping. The first express pump of large capacity was run at between 200r.p.m. and 300r.p.m., but this speed has been gradually reduced to 120 to 180 revolutions, which is an immense advance on the old-fashioned slow-speed pumps at 50 to 80 revolutions, and

still allows of the use of electric motors of fairly economical design and low first cost.

For small pumps the speed may be somewhat higher, and for such pumps belt driving is advisable if there is enough space in the pump-room, the loss in the belt being equalised by the higher efficiency of the motor.

The latest electrically driven mining pump (in the opinion of the writer, destined to supersede all other pumps and first of all the steam-driven pump) is the electrically driven high-pressure centrifugal pump. The centrifugal pump is an ideal mining pump on account of its many and valuable qualities, *i.e.* (1) cheapness, about one-sixth; (2) small dimensions and compactness; (3) strong construction and almost absolute security from breakdown; (4) possibility of pumping dirty and gritty water, and (5) small pump room required. The commercial construction of high-pressure centrifugal pumps is of recent date, but any lift can now be obtained with a single pump up to 750ft., and for higher lifts with two or more pumps in series.

The first large installation erected on this principle was the pumping plant for the Hocayo Mines in Spain. Small centrifugal pumps driven by electric motors were installed on each pumping level as the workings increased in depth. The pumps needed no supervision, and the loss of energy usually incurred by letting the water flow and accumulate in the sump at the pit bottom was avoided. Another advantage was that the capacity of the installation could be gradually increased with very little cost. With plunger pumps, either steam or electrically driven, a division of the pumping plant in this manner would be impossible owing to the high capital costs, and still higher rate of working costs. The water pumped from its proper inflow level is also much cleaner, and has therefore a certain value when brought to the surface.

Modern high-pressure centrifugal pumps may be divided into two distinct classes, *i.e.*, the Sulzer Pump and the Rateau Pump. Various firms in this country, on the Continent, and in the United States manufacture either of these types on license, or a pump of their own which may be more or less a combination of both principles.

The Sulzer pump consists of one or more rotating impellers containing spirally curved guide blades and fixed guide wheels provided with spirally curved water passages. The water is thrown radially against the fixed guide wheels and through openings in the latter, back again against the blades of the next propeller, which throws it through openings in the periphery of the fixed guide wheel in the pressure chamber surrounding the guide wheels. Thence, the water flows through channels to the next impeller system, or to the discharge if it is a single stage pump. Gradually the velocity is transformed into pressure by means of expanding channels. This pressure varies, of course, with the speed of the impellers, but it may be taken as about 225 feet of head per impeller stage. With four impellers, therefore, a head of 800ft. may be taken as normal. For higher lifts two pumps in series coupled to one motor in the centre may be used with advantage. The impellers and guide wheels are made of bronze. The axle, of nickel-steel, is supported on two self-oiling bearings. Another great advantage is the ease with which the wheels can be changed, and even with the largest sizes it does not take more than two hours. Only spare impellers and guide wheels need therefore be kept in reserve, instead of a complete pumping set as with plunger pumps. The pumps are coupled to the motors by means of elastic couplings. The suction pipe is provided with a safety valve and foot valve, the former of which prevents the water in the rising main from entering the pumps and pressing against the foot valve.

The first important installation of centrifugal pumps of high capacity against a head of over 1800ft., placed at the pit bottom, was carried out at the Victor-Rauxel colliery, Westphalia. Two pumps are installed in series, each having a capacity of 1500 gallons

of water per minute, against a head of 900ft. This plant has now been running for two years, night and day, without a single hitch. An official test showed the following results: Steam engine 90 per cent., generator 94 per cent., cables 99 per cent., motor 93 per cent., and pumps 75 per cent., the total efficiency being 59 per cent.

The Rateau pump is built on another principle, as the water does not leave the impellers in a radial direction, but in an axial one. In the Sulzer pump the water flows on the impellers in an axial direction and is thrown out radially; but in the Rateau pump the water enters the passage of each impeller at the centre, and by the rotation is forced out to a collecting chamber surrounding the periphery of the impeller. The ducts which return the water back to the centre of the impeller are suitably curved to act as guide passages, similar in action to the guide buckets of a turbine. The water then enters the impeller in an axial direction, its rotary motion having been transformed by the guide passages into rectilinear motion. Many pumps have been built on the Rateau principle in Germany, as well as in the United States, and a combination of the Sulzer and Rateau pumps forms the Schwarzkopf pump. Centrifugal pumps are mostly provided with a special balancing arrangement (that of the Sulzer being kept secret) usually consisting of a hollow plug at the bottom of the chamber adjusted by screws, causing the impeller system to balance by the reaction of the water. This compensates the resulting end-thrust in horizontal pumps, and in a vertical sinking pump the excess pressure of the water.

The efficiency of the Rateau pump is slightly higher than that of the Sulzer pump, and may be taken at between 65 and 80 per cent. It can be used for pumping smaller quantities of water at greater heads, while the Sulzer pump is more adapted for larger quantities at lower heads. So far as their appearance and construction are concerned, the Sulzer pump has few wheels of large diameter, while the Rateau pump has many wheels of small diameter; in fact, it closely resembles the Parsons turbine. The number of wheels on a Rateau pump for a head of 600ft. varies from 8 to 10, necessitating a long pump body and a high speed. In fact, the increase of pressure per wheel on a Rateau pump is about 1.5 to 2 atmospheres, while in a Sulzer pump it reaches 25 atmospheres.

A recently installed Rateau pump in the Carmaux Colliery, France, has a capacity of 80 gallons per minute to a vertical head of 1350ft. at a speed of 2900r.p.m.

Electric Motors.

The electrical part should consist of a high-speed, three-phase motor, because it is the cheapest and best-adapted electric motor for colliery purposes, and may be worked up to an output of 100h.p. without a starting switch. Instead of the latter it is equipped with a centrifugal compensator, which can be made completely gas and water tight, and which cuts out the starting resistances automatically. The point is to construct a motor running at a medium speed and well ventilated, so as to show no high temperature rise after a twenty-four hours' run. Another required condition is the possibility of regulating the position of the stator part of the motor, as the small clearance between the rotor and stator with three-phase motors (continuous-current motors are not very suitable for underground pumping) soon necessitates a readjustment of the clearance after continuous running perhaps for several months without stopping. For large motors it is essential that they should be constructed in several parts, so as to permit of easy transport in the shaft and narrow roadways. Motors of a capacity of 200h.p. and more should be provided with slip rings, and these should be completely closed, so as to be water and gas tight. They must be so well ventilated that after continuous running for any length of time their temperature limit is not reached.

A three-phase motor of modern construction may be considered free from breakdown, and it is, therefore, not necessary to provide

spare units. It is good practice to mount the motor between two pumps, one being a spare, or between the two cylinders of a two-cylinder pump. Direct driving, although not absolutely necessary, is to be preferred, especially for large sets. If gearing is used, bronze wheels and raw hide pinions should be employed, in order to avoid noise, which is most objectionable in a mine and constitutes a danger. The motor may also be mounted side by side with a three-cylinder pump, but this arrangement has the disadvantage that all parts of the pump are not so easily reached as with the motor placed in the centre. In the former case, however, the motor should be provided with a revolving mass, either in the rotor or in the shape of a separate flywheel, so as to ensure an even turning moment.

Of course, where existing slow-speed steam pumps have to be converted into electrically-driven pumps special motors must be built, and this sometimes necessitates very special design. In a case within the writer's experience a steam-driven pump making 68r.p.m. had to be converted by replacing the steam cylinder by a 150h.p. three-phase motor, working at a periodicity of 21, and therefore requiring 38 poles. This, again, required a large stator, which had to be specially stiffened by means of end shells, so as to ensure safety from breakdown, with a clearance of only 0.07in.

Specially stiffened frames, however, are very expensive, and a very small clearance is in every way undesirable from a running point of view. This may be avoided by using a motor with a double armature, having about half the diameter of an ordinary slow-speed motor, but more than double the length, which is no disadvantage. Two rotors and two stators are placed next to each other and combined into one. Each stator and each rotor has therefore half the normal windings and half the number of poles. This construction has still another advantage. We may cross-connect, or rather change, the electric junctions of the one rotor for the other stator winding, *i.e.*, if we connect directly the right-hand rotor winding to the left-hand stator winding, both forming, therefore, a short-circuited winding without slip rings, and may be former wound. The second half of the secondary winding is on the right-hand stator, and may, therefore, be ended at fixed terminals. The stator may be connected to a three-phase starter. The motor has, therefore, no slip rings, and is eminently suitable for use in fiery mines.

Much depends, of course, on the regularity of the pumping. If the flow of water to be removed is constant, then the pumps can be run direct from the power-station mains. In small pumping plants, if the flow varies very much the pumps may stand idle during the hours of less flow, but with large installations that is hardly practicable. In the latter case, the pumping plant must have its own electric generating plant at the power-station, *i.e.*, its own dynamo and spare plant, so as to vary the speed of the pump by influencing the generator-field through a separate exciter, and also the steam-engine speed. This ensures a speed regulation without incurring the losses of a speed control through resistances. This arrangement is only, however, to be recommended for large pumping plants (300 to 500h.p.), as the generator units in the power station will be about that size. In both cases, however, employing either a separate dynamo or direct driven from the mains, there should be a starting arrangement in the mine as well, and the motor should be provided with slip-rings. In the case of emergency the man in the pump-room should not be obliged to ring the power-station, but should be able to shut down the pumping plant himself. A telephone should always be installed between the pump-room in the mine—which is used at the same time as a general distributing room for the electrical energy—and the power-station on the surface.

The introduction of the high-pressure centrifugal pump, with its simplicity, small dimensions, lightness, and high speed, has altered completely the aspect of sinking by

electricity, and the writer contends that an electrically-driven centrifugal pump is unrivalled for sinking purposes on all points.

The compact and small design of the electric sinking pump are readily recognised. The construction, though simple, must be carried out in a very thorough manner, and the writer is glad to say that many have been built here and on the Continent which yield excellent results.

The motor, mostly three-phase, turns round a vertical axle, and must therefore be carefully balanced and protected from the dripping water. The weight of the rotating part is carried on a ball-bearing, protected by a tightly closed hood, which also encloses the starting device. The lower bearing is formed by the stuffing-box of the centrifugal pump. The pump-axle is made in one with the motor shaft, and is supported on another bearing fixed in the pump casing. The bottom part of the motor casing is shaped in such a way as to form one with the pump, without, however, preventing access to the stuffing-box. The top part of the motor casing protects the motor from any water spray. The windings are, of course, extra well insulated, so as not to suffer from dampness in the shaft. The starting device is mounted on the pump, as it is found better to start and stop the pump at will in the shaft, without signalling to the surface. The simplest device is the centrifugal automatic starter, which may be used with motors up to 100h.p., and can be easily enclosed so as to be air and water tight. For powerful pumps, in cases where variations of the voltage are not allowed starting resistances must be used.

Surface Plant.

The application of electric motors to surface plant, such as motor generators for lighting, brickworks, lamp-rooms, shops, mortar-mills, creepers, crab-engines, compressors, lifts, &c., need not further be enlarged upon, as their application presents no difficulties and is now generally adopted at most collieries.

Coal Cutters and Drills.

Coal cutters and electric drills, however, belong to a class which present far more difficulties on account of the rough treatment they receive and the heavy work expected of them.

The question of safety is also of supreme importance with this class of machinery, and apart from loss of life, the new Compensation Act is a reminder to mine-owners to spare no efforts and expense in this direction. The electrical drive against compressed air is largely a matter of sentiment with mine managers, and there is nothing to choose between the two either on the score of cost, repairs, or ease in handling. The air-compressor plant and pipes, however, introduce a very inefficient link between the power-station and the tool, and a source of constant leakage and loss. Where electric coal cutters or drills are barred on some exaggerated idea of danger from explosion, a small electrically-driven compressor should be fixed at the nearest gateway. Special care should be taken with the gateway switches, trailing cables and sockets, motors and starters. The cables should be wire-armoured and leather-braided, and all switchgear should be of the iron-clad fool-proof design. The motors must be of extra-strong design on account of the heavy vibration, and the field coils should in all cases be clamped to the magnets. All connections must be inside the framing and protected by rubber tubing and whipcord. The starting switches must be in flame-tight casings, and should be preferably of the double-pole drum type. The frames and switch-cases should be well earthed.

Three-phase motors are to be preferred, and will in time completely oust direct-current motors on account of the brush trouble with the latter. The absence of resistances in the case of squirrel-cage motors is, of course, a great advantage, and for powers up to 20h.p. these are the motors the writer advocates in many cases.

The electric drill is not so readily adopted

yet as the electric coal-cutter, and its use in collieries is limited at present to the driving of headings, sinking work, and it is, therefore, mostly out of the danger zone. Still, their introduction is well worth considering, on account of the ease with which they can be installed and the small amount of power they consume in comparison with air drills.

The writer divides these drills into two classes in accordance with the well-known methods of drilling by hand :—(*a*) the direct percussion drill, where the drill steel is directly connected to the piston, or other reciprocating mass, (*b*) the indirect or so-called hammer drill, where the swinging mass deals a series of blows on the drill steel. The latter class, although at present only represented by one make, is claimed to possess several advantages, and may be expected to be largely used in the future. Among the drawbacks often urged is the difficulty in pulling the drill out of the hole after having stuck, and also the liability of heating of the surfaces of the piston and borer-head. On the other side it may be argued that nearly all friction losses in the borehole can be neglected. It is also much easier to provide for water spraying through the hollow stationary borers than through the moving borer. The box drill is at the present the only hammer type drill on the market, and bids fair to take an important place in modern mining equipments, especially on account of its lower maintenance cost.

Comparatively little is known in this country of the various types of electric percussion drills at present on the market, described below. Three distinct types will be considered :—(1) purely electrical or solenoid drills ; (2) Hoffmann or spring drills, with the air cushion variation, the box drill ; (3) the Temple or pneumatic spring drills, with electric-driven air-pump.

The rock drills coming under class (2) are the best known ; they can be further subdivided according to the position of the motor. The geared motor mounted on the drill frame is, however, gradually supplanting the separate motor and flexible shaft coupling, thus avoiding the somewhat heavy repairs to the flexible shaft.

The tables below give comparative figures for the various types of drills mentioned above.

Utilization of Coke-Oven Gases for Power Generation.

Many, but still relatively few, coking collieries utilize the spare gases from their coke ovens under steam boilers which supply steam to the auxiliary plant, and sometimes to continuous running plant, *i.e.* air compressors and pumps. On account of their intermittent steam consumption it is often preferred to run winding engines from separate coal-fired boilers.

The wasteful character of this method as compared with the direct combustion of the gases in an internal combustion engine need not be insisted upon. To estimate the magnitude of this loss one has only to remember that of the quantity of coke produced in Great Britain in 1902—10,000,000, tons—only about 10 per cent. was produced in

	Solenoid Type.				Spring Type.			
—	Marvin 1.	Marvin 2.	Marvin 3.	Union Drill.	Old type Siemens Schuckert.	Adams Drill.	Box Drill.	Temple Drill.
Weights of moving parts in kg..	18	34	45	—	25	22	45	33·3
Stroke at full power in m/m	113	138	165	—	78	100	140	188
Blows per minute..............	400	400	400	—	450	600	600	425
Output in h.p.	0.45	1.2	2.3	0.66	0.4	1.45	0.58	2.8
Input in h.p.	4	5	6	4	1.33	2.4	1.77	5.5
Efficiency	11%	25%	38%	18%	30%	60%	33%	50%
Weight in kg.........	56	133	167	92	108	133	110	125
Weight per h.p. output	124	106	72	135	270	92	190	45
Weight of motor in kg.	—	—	—	—	45	67	40	400*

* Together with Air Pump.

by-product ovens. If it be assumed that most of these gases after being freed from tar, ammonia and benzol are passed under boilers about 10h.p. per oven will be obtained.

Modern by-product ovens yield about 78 per cent of coke on a charge of four tons of coal per oven. Using water-tube boilers 1¼lb. of water on an average can be evaporated per 1lb. of coal coked in the ovens, where the by-products are actually being recovered. As 30 to 40 hours elapse between each charge, about 11,000lb. of steam are generated and about 10b.h.p. per oven is produced.

When burned directly in a gas engine, taking about 25 cubic feet of gas per b.h.p. hour, the amount of power per oven is about 25b.h.p. on the engine shaft, or twice to three times as much as when burning the gases under steam boilers. This estimate assumes that the coal produces 15,000 cubic feet of gas per ton of coal and that 25 per cent. of the gases are available for power purposes. This calculation shows the great saving in power, and therefore in coal (which is now burnt under boilers in collieries), to be derived from using the gases in gas engines, even in comparison with the most up-to-date steam plant. There are many collieries on the Continent and in the United States where coal is not burnt in a single boiler for power requirements, including coke ovens, washeries, air compressors, winding engines, pumping engines, &c. This implies a saving in coal of 3 per cent. to 5 per cent. on the output, a figure which must be considered now that managers are coming back from the old and mistaken idea that "slack costs nothing at the pit mouth."

Generally speaking, when introducing gas engines, by-product ovens will be required, and the saving in efficiency alone which these ovens represent over the old type of beehive ovens will amount to about £2,500,000 in Great Britain. Add to this the sale of by-products, worth about 4s. 6d. per ton of coal coked, and one may realize the saving which will be derived from the wholesale adoption of by-product ovens and gas engines.

Of course, all coals are not suitable for this coking process, as the quantity of spare gas is very variable. Many coals with a small percentage of volatile matter, say South Wales coals with 15 to 18 per cent., requiring a very high coking temperature, only give off enough gases to heat the walls of the coke ovens and leave no surplus gases. Of course, by suitably heating the flues, or, better still, the air supply (regenerative ovens), it is always possible to obtain a saving in gas of about 20 per cent. From good coking coal, such as Durham, Silkstone, &c., with a percentage of volatile matter varying between 20 to 30, it is easy to utilise from 20 to 40 per cent. of the total gas production for power purposes in gas engines. Coals with a very high percentage of volatile matter, such as Durham gas coals, need a very much higher temperature to produce a hard coke, and, therefore, do not leave more surplus gas than coal of a medium percentage.

Another important point influencing the amount of surplus gas is the quantity of water present in the coal; with washed coal, often containing 15 per cent. of water, the amount of heat, and therefore gas, required to evaporate this water is very considerable.

It is quite possible, and even desirable, to combine both systems, and to pass the gases which have been partly cleaned and freed from by-products, after heating the flues and regenerators, under steam boilers, while the surplus gases are taken direct through additional cleaning plant to the gas engines.

There is, however, another direction in which the surplus gases may be used, and in the United States there are many coking plants which supply neighbouring townships with gas for lighting purposes. The gases are carburetted with benzol and compressed in order to distribute them over distant districts, as the Mond Gas Company is doing in South Staffordshire. This, of course, eliminates the objection that there are no consumers

near the coke ovens requiring the surplus gases for lighting purposes. One must not forget that the efficiency of these gases when used for lighting purposes is about fifteen times as much as when used under steam boilers, and this application, therefore, is worthy of consideration.

But by far the most important field for the utilization of surplus gases is the direct-driving of gas engines. Roughly speaking, the writer has found in many cases that the cost per unit in coke-gas power stations of medium size is about 0.1d. to 0.2d.

The production of cheap power at collieries is a question gaining in importance every day, proportionately to the drop in price of the saleable article and the increased depth of the pits. The firing of steam boilers by means of small coal at the pit is an expensive method, and if no rubbish and refuse from the washeries are available, a very wasteful process, having regard to the low efficiency of the boilers. Even taking the value of this small coal at from 2s. to 4s. per ton at the pit mouth, the saving of coal by using gas engines is a substantial item. Moreover, small coal and washed peas have a market value nowadays; and it will not be long before a fuel will be made out of the waste heaps, which will consequently raise the commercial value of all small stuff at the pit mouth. Every modern colliery should either, therefore, burn its rubbish and waste in gas producers, or else compress and coke it in by-product ovens, using the gases obtained in both processes for generating electric power by means of gas engines.

Cell Regulators.

The Union Electric Company, Ltd.

IN the course of its development in the Switchboard Department, this Company has found the necessity of providing several pieces of special apparatus suitable for the widely varying requirements of its clientèle. One of the branches requiring special work has been the construction and application of charge and discharge cell regulators for private installations and public central stations. Most private stations, in view of the first cost, have adopted the hand regulator, an illustration of which is given in Fig. 1. The illustration shows a double-cell regulator providing for regulation both on the charge and on the discharge wires from the battery. The discharge regulator is usually fitted with the powerful hand-wheel shown, while the charge regulator is controlled by the lever handle.

It will be noticed from the illustration that both the charge and discharge are provided with leading fingers and suitable resistance connecting the leading fingers to the main contact brush. The brushes are both laminated and constructed of special metal so as to retain their springy nature and provide the very best possible contact. The contact plates connected to the various regulating cells are imbedded in the special material of which the regulator base is constructed. The centre shaft passes through a widely flanged hub, in which are provided a series of small counter-sunk holes, so as to absolutely determine the position of the contact brushes and prevent any current passing continuously through the leading finger resistances.

The number of ways on these regulators, owing to the construction of them with imbedded

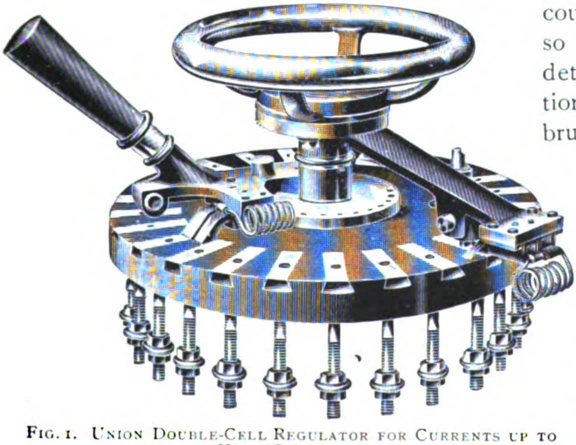


FIG. 1. UNION DOUBLE-CELL REGULATOR FOR CURRENTS UP TO 250AMP. AND HAND OPERATION ARRANGED FOR TWENTY-TWO REGULATING CELLS.

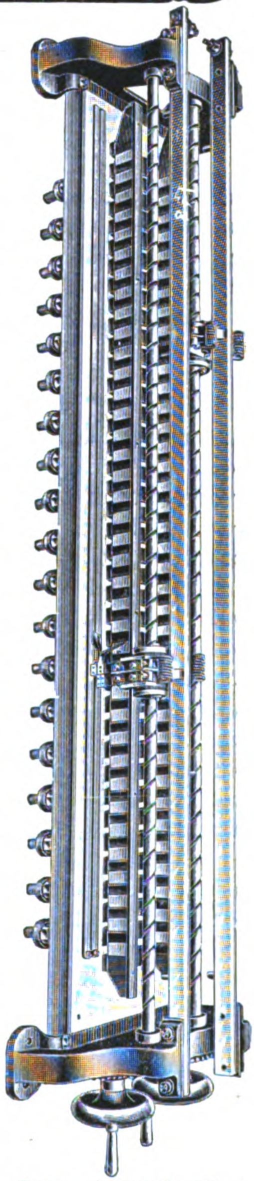


FIG. 2. LARGE CELL REGULATOR FOR CENTRAL STATION WORK. 850AMP., 38 REGULATING CELLS AND SUPPLEMENTARY CELL-TESTING CONTACTS.

contacts, are standardised in two quantities for each ampere rating. The usual range in this class of switch is from 30amp. up to 235amp. and the number of regulating cells either 13 or 21. Should it be decided to use a less number of regulating cells it is generally found better commercially to connect several of the contacts together by a copper strip instead of constructing a special regulator, although this can be done if desired. In such a case the parts are mounted either on slate or marble, with filling-in pieces of glass between the contacts, with properly rounded off edges to prevent a contact path being carried between adjacent cell contacts.

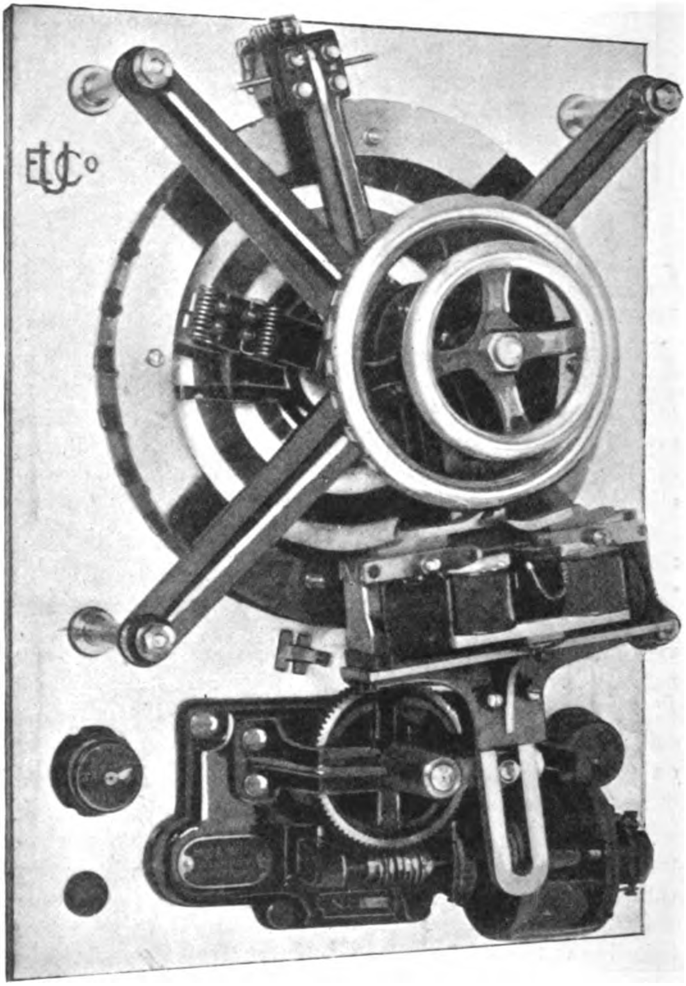


FIG. 3. UNION AUTOMATIC CELL REGULATOR FOR SMALL INSTALLATIONS, SHOWING THE DRIVING MOTOR AND GEAR.

For central-station installations, where the current to be carried is great, and also where it is advisable to have a large number of regulating cells, the straight line pattern of cell regulator has been designed. This type is shown in Fig. 2, which represents an apparatus as used for currents up to 1000amp., and for as many as 45 regulating cells. For the larger sizes of apparatus, the contact brushes are fitted, in addition to the leading finger and its resistance, with a magnetic blow-out, and the design further permits of the addition of brushes connecting to a special set of contact-bars for voltmeter measurements.

In many installations, however, it is not sufficient to have a hand regulator, owing to the more or less constant voltage regulation required, and regulators have been constructed, both of the circular pattern and of the straight line pattern for automatic control driven by electric motors. The illustration Fig. 3 shows a circular pattern double cell automatic regulator, usually fitted on a marble base, and provided with a driving motor. The speciality of this arrangement is that the motor, which is switched into circuit by the contact voltmeter, runs always in the same direction, and communicates its motion to the regulating switch-lever by means of detents. When high voltage is present one detent works and drives the switch-lever in one direction, and when low voltage

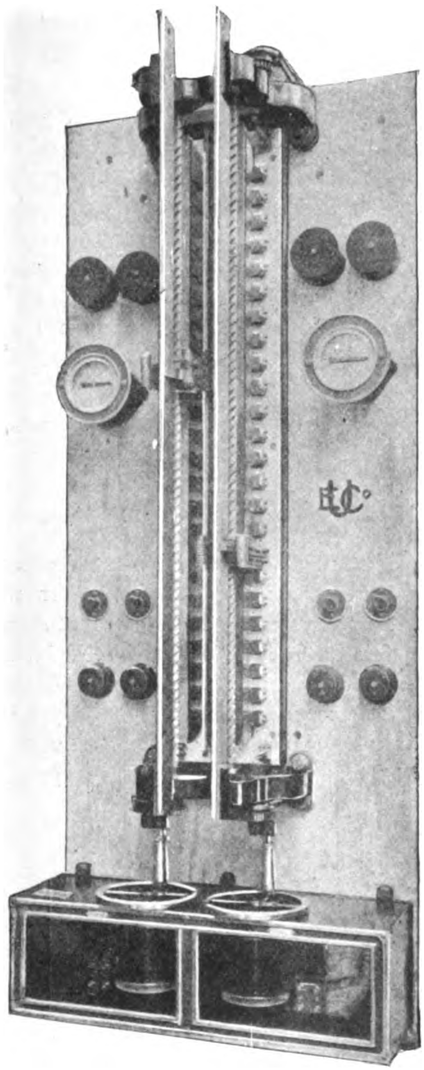


FIG. 4. UNION AUTOMATIC CELL REGULATOR FOR CENTRAL STATION WORK, SUITABLE FOR 600AMP. AND ARRANGED FOR THREE-WIRE SYSTEM WITH 48 REGULATING CELLS.

is present another detent engages and drives the switch lever in the opposite direction.

The mechanical design is such that full and accurate steps are always made in each direction, and there can therefore be no risk of a cell being left to discharge through the leading finger resistance. Apparatus of this kind is usually made with twenty-two regulating ways. For larger cell regulators carrying current up to say 1000amp., a different pattern of automatic regulator is used, and this is shown in the illustration Fig. 4, which shows a double cell regulator for 600amp. This is entirely automatic in its operation.

The illustration shows on the right and left sides current direct indicators, also press-buttons for controlling the position of the cell switch by hand, and various fuses. The push-buttons and contact makers can be placed at a considerable distance from the cell regulator, thus enabling the cost of the many and heavy conductors usually required for a cell regulator to be considerably reduced. When necessary, regulators of this kind can be fitted also with an indicator which will indicate at a distant point the number of cells in circuit.

Oil-immersed Motor-starters for Polyphase Circuits.

The illustration, Fig. 5, shows the standard pattern of oil-immersed polyphase starter as made by the Union Electric Company, Ltd., and chiefly adopted for use in mining work. It will be seen that the apparatus consists of an oil-tight cylinder, with three porcelain inlet ways; plunged into the cylinder is the resistance coil arrangement, consisting of wires carried on porcelain insulators

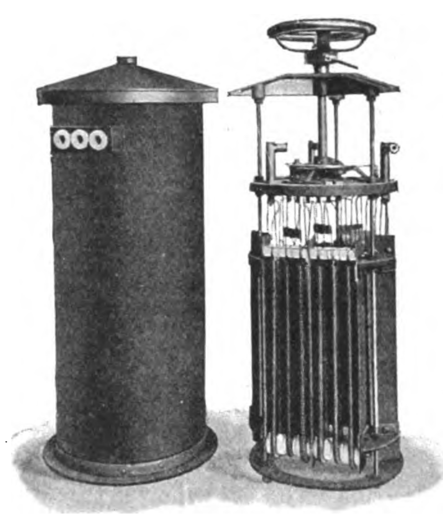


FIG. 5. OIL-IMMERSED THREE PHASE MOTOR-STARTER.

FIG. 6. "FORTITER" OIL-IMMERSED AND WATER-COOLED STARTER FOR THREE-PHASE, HEAVY DUTY, MINING OR ROLLING MILL MOTOR.

terminated in a stout contact plate having on the top of it a three-way brush switch. The terminals connected to the brushes are carried at an elevation enabling not only the resistance coils, but also the contact plate, to be kept under oil.

Apparatus of this kind can have interlocking gear fixed to the main or stator switch, so that it cannot be closed except when all the resistance is in circuit with the rotor of the three-phase motor. The apparatus can be also fitted, in place of the hand-wheel shown, with bevelled gear, so that a shaft can be carried at right angles to the vertical spindle through the face of the switchboard, where the operating handle may be placed. When desired in connection with this apparatus a slow-motion device can be attached, so that every precaution necessary for the proper starting of the motor can be obtained with the standard form of apparatus.

When, however, the load is exceedingly heavy and starting takes place at rapid intervals, and especially where slow-motion starting is in vogue, it is desirable to have a special form of oil-immersed starter, and this is shown in the next illustration, Fig. 6. The external appearance is not unlike that of the previously mentioned motor starter, but in this case a water-filled copper coil passes through the oil, and this by means of the circulation of water carries off fairly rapidly the heat discharged from the resistance wires into the oil. If necessary the current-carrying and water-carrying coils can be specially arranged so that this form of starter can be used for speed regulation, even on quite large-size motors. The standard range for Union oil-immersed starters of this class is from 6b.h.p. up to 250b.h.p.

Motor Starter for Heavy Motors.

The illustration Fig. 7 shows a "Fortiter" motor starter particularly suitable for the automatic operation of large-size motors up to as high as 100h.p. The same general principles apply in these starters, whether used for starting direct-current or polyphase motors. The particular starter shown is suitable for 70h.p., 500-volt, polyphase

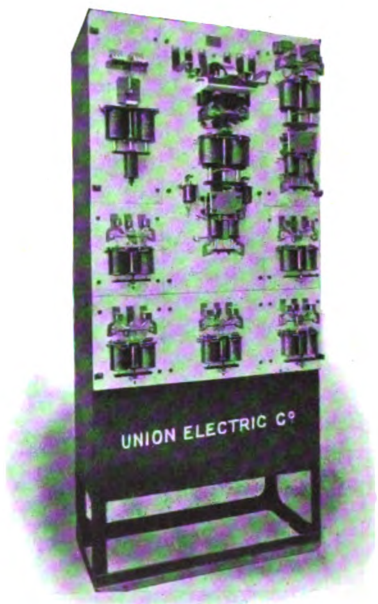


FIG. 7. "FORTITER" AUTOMATIC STARTER FOR 70H.P 500-VOLT THREE-PHASE PUMPING MOTOR

motors. The operating circuit can be worked either from a float contact arrangement, from a press button, or from a contact pressure gauge. The closing of the contact in this circuit excites a relay which energises a solenoid switch. When working with a direct-current motor the other relays which are connected to the armature of the motor close at different predetermined voltages, so that the resistance is cut out exactly at the correct moment when the motor has built up speed so as to reduce the starting current passing into it to about normal value. The apparatus is so constructed that the supplementary relays do not come into circuit until the main motor circuit itself is closed by means of the solenoid switch.

When the starter is intended for polyphase motors, as it is impossible to arrange for the supplementary relays to be operated by the increasing voltage of the rotating part, an automatic time limit is included which is wound up by the main solenoid switch. By this arrangement the various resistances are cut out one after the other at predetermined times, not as in the case of the direct current motors at predetermined voltages.

Noteworthy Contracts.

Johnson & Phillips, Ltd.

THE following are particulars of some of the more interesting and important contracts carried out by Johnson & Phillips, Ltd., during the year now nearly closed.

Avonmouth Docks.—A complete cable, arc lighting and glow lighting installation for the Avonmouth Docks. This comprised the supplying and laying of several miles of underground paper-insulated lead-covered and armoured feeder, distributor and arc lighting cables for supplying power to the various grain-conveyors, cranes, and capstans; and current for lighting to over 100 arc lamps outside and about 2000 ordinary glow lamps inside the various sheds, offices, &c. The contract also included the supply and erection of a main switchboard and all the sub-boards throughout the docks.

Birmingham Tame & Rea Drainage Board.—This contract is for a complete installation for the new storm-water pumping installation of this Board at Saltley.

Electric supply at 6000 volts is taken from the neighbouring Supply Company, through a length of underground cable and overhead transmission line, the distance from point of supply to the pumping station being about one mile.

The cable is of J. & P. standard paper-insulated type with a special B.O.T. earth shield. The overhead line calls for no special comment, being of the usual type of construction. The bare conductors are supported on J. & P. triple shed porcelain insulators mounted on brackets bolted to wooden transmission poles. The line supplies to the pumping station through an E.H.T. switchboard of standard J. & P. construction. The 6600-volt oil switches are contained in special concrete cubicles, all gear on the panels being at low pressure.

The motors driving the pumps are supplied at two pressures, the larger ones at 2200 volts and the smaller ones at 200 volts. The reduction in pressure is effected by means of an installation of J. & P. transformers which are erected underneath the switchboard gallery. The motors are all of the squirrel-cage induction type, consisting of two 55b.h.p. motors working at 2200 volts and two 10b.h.p. motors working at 200 volts.

In addition to this Messrs. Johnson & Phillips supplied and erected twelve electrically-operated sluice-valves. These valves are driven by small ½b.h.p. motors supplied by overhead lines from the pump house and controlled by throw-over switches on the main board. Two sets of lines are run to each valve so that the same can be opened or closed by reversing the switch position, and thus reversing the motor.

Colliery Work.—During the year this firm have installed several overhead transmission lines for collieries, the principal ones being a

3000-volt line for the Hucknall Torkard Colliery Company, Nottingham, and two 3300-volt lines for the Lochgelly Iron and Coal Company, Ltd., Lochgelly. A complete set of shaft and in-bye cables of the J. & P. V.B. armoured type is also being installed for the Lochgelly Iron & Coal Company, four of their pits being equipped. Other pits in Scotland are also being equipped. As regards colliery switchgear a contract now in hand is the installing of a complete switchgear equipment for the Fife pits of the Lochgelly Iron and Coal Company, Ltd., with oil switches.

Tramway Work. — During this year Messrs. Johnson & Phillips have installed complete e.h.t. switchgear equipments at six of the L.C.C. substations, the contracts comprising the erection of all the white glazed brickwork cells, switchgear, transformers and machine cables. Several miles of underground feeder and telephone cables have also been supplied and laid on the L.C.C. Northern system.

The firm have also carried out the overhead work for the new railway being built at Kinlochleven by the British Aluminium Company for their new factory. The electric locos are equipped with a bow trolley and a great deal of work of a special nature has been involved.

New Catalogues.

Cranes.—ADAMSON, RAMSBOTTOM & CO., LTD., BIRKENHEAD. This firm's latest catalogue shows some of the types of electric and hand cranes in which they specialise. Numerous half-tone illustrations are given, a number of which show cranes that have been designed to meet special requirements.

Switchboards, Arc Lamps, &c.—THE UNIVERSAL ELECTRICAL MANUFACTURING COMPANY, PECKHAM, S.E., send us a very complete catalogue built up on the loose-leaf principle, the various leaflets describing and illustrating switchboards and switchgear, arc lamps and accessories.

Arc Lamps.—ELECTRIC AND ORDNANCE ACCESSORIES CO., LTD., BIRMINGHAM. This firm's latest arc lamp catalogue, A.41, deals with the "Victor" standard, miniature, and flame arc lamps for direct-current circuits. The list also includes prices and illustrations of arc lamp globes, accessories, and resistances.

Machine Tools.—BATEMAN'S MACHINE TOOL CO., LTD., LEEDS. This publication, which is well illustrated, deals with the well-known Bateman planer from the works' costs point of view, demonstrating the economy of installing these machines for various services.

Centrip Gear.—DAVID BROWN & SONS, LTD., HUDDERSFIELD, send illustrated booklet describing the Centrip Gear (Spence's Patent). The makers claim that the gear possesses, amongst others, the following advantages:—The high and low speed shafts are in line; all pinions and wheels are cut from solid steel blanks; the high-speed pinion is of nickel steel; all pinions are case-hardened; the gear is totally enclosed and runs in an oil bath; the losses due to friction are small owing to the use of ball-bearings; the meshing velocities are usually less than half those of open reducing gears, as, owing to the triple gear contacts, much smaller wheels are used; the mechanical efficiency is consequently high, and wear and tear at a minimum.

Arc Lamps.—THE GILBERT ARC LAMP CO., LTD., CHINGFORD, ESSEX, have issued an attractive showcard giving illustrations and prices of enclosed, miniature, and flame arc lamps. Copies of the showcard will be sent to electrical contractors gratis on application.

A.C. Motors.—G. WÜTHRICH, LONDON, W.C. Lists Nos. L.32—p.14/16, give prices, weights, dimensions and outputs of the Oerlikon three-phase squirrel-cage induction motors, from $\frac{1}{8}$ to $8\frac{1}{2}$h.p. and from 12 to 85h.p. respectively. Mr. Wüthrich, whose address is Oswaldestre House, Norfolk Street, Strand, will be pleased to send copies of these lists to anyone interested.

Lamps, Bells, Telephones, &c., &c.—JOHNSON & PHILLIPS, LTD., CHARLTON, S.O., KENT, send a number of leaflets giving prices and illustrations of various specialities. Leaflet D deals with alternators, exciters and regulators and gives prices for single, two, and three-phase alternators at various speeds and voltages. Leaflet J gives prices of searchlight projectors of standard sizes. Leaflet S illustrates and gives prices of various patterns of shades for incandescent lamps, with particulars as to colouring and dimensions. Leaflet T is devoted to cut-out boards, switches and various accessories. Leaflet U deals with telephones for domestic use and also for battery call and magneto call, as well as portable testing, telephones. Leaflet V gives prices, illustrations, &c., of electric bells, indicators, Leclanché battery cells, &c. Leaflet W deals with electric radiators and cooking apparatus, the latter including electric kettles, saucepans, plate warmers, &c. List X deals with transformers for metallic-filament lamps, particulars being given of the iron losses, voltage drop and efficiencies of several sizes of transformers of various ratios.